ENERGY ALTERNATIVES FOR ATLIN, B.C.

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Atlin Advisory Planning Commission

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ENERGY ALTERNATIVES FOR ATLIN, B.C.

Executive Summary

This northwestern British Columbia community, approximately 30 miles south of the Yukon border, has experienced a gradual growth in tourism, a rejuvenation of placer mining and an increasing interest in pioneer lifestyles. Its population is about 340 yearround, swelling by about a third in the summer.

The community commissioned this study to: identify how energy is being used; identify alternatives to oil; explore waste heat recovery opportunities; and review available B.C. Hydro studies on possible Pine Creek small hydro development.

The approximately 70% of Altin residents heating solely or in part with wood used 2500 m^3 in 1983. With an approximately equal amount being harvested for timber and other purposes, the life expectancy of the nearby forest resource is 545 years. Home heating oil is the second most popular source for space and water heating. The community's diesel-generated electricity is used for lighting, appliances and power tools, but seldom for space heating.

The study concluded that, at a 100% load on the community's diesel generators, heat recovery could save about $110,000 worth of fuel oil a year. The heat recovery system and distribution costs are estimated at approximately $400,000. Cousumers could expect to pay between $14 and $100 per million BTU, depending on their distance from the system.

The other energy source that appears to be viable is small scale hydro. A conceptual design and cost estimate are provided for four potential sites on Pine Creek. The cost to the community of buying diesel-generated electricity from B.C. Hydro at a subsidized rate of 5.66 ¢/kWh is cheaper than the estimated cost from either of the two most promising small hydro sites (6.0 and 6.5 ¢/kWh). Nevertheless, with Atlin residents looking at a possibly higher cost to buy electricity in the future, the idea of increased self reliance from their own small hydro source is appealing.

A number of other alternatives to oil are not considered feasible. These include natural gas, coal, geothermal springs, solar heating, wind and peat.

The study was conducted for the Atlin Advisory Planning Commission by Reid Crowther and Partners Limited with a contribution from the Remote Community Demonstration Program of Energy, Mines and Resources Canada.

OPTIONS ÉNERGÉTIQUES POUR ATLIN (C.-B.)

Résumé

La collectivité d'Atlin dans le nord-ouest de la Colombie-Britannique, à quelque 30 milles au sud de la frontière du Yukon, a connu une croissance progressive du tourisme, un renouvellement de l'exploitation des placers et un accroissement d'intérêt à l'égard de la vie pionnière. La population permanente de quelque 340 habitants augmente d'environ le tiers en été.

La collectivité a commandité la présente étude pour: déterminer les modes actuels de consommation d'énergie; déceler les options de rechange pouvant remplacer le pétrole; explorer les possibilités de récupération de la chaleur résiduelle, et examiner les études de la B.C. Hydro relativement à l'aménagement d'une petite centrale hydro-électrique au ruisseau Pine.

La proportion d'environ 70 % des résidents d'Atlin qui chauffe entièrement ou en partie au bois, en a consommé 2500 m^3 en 1983. Étant donné qu'un volume comparable est récolté comme grumes ou à d'autres fins, on estime à 545 ans la durée prévue de la ressource forestière située à proximité. Le mazout vient en deuxième lieu comme source d'énergie pour le chauffage des locaux et de l'eau sanitaire. L'électricité, produite sur place par groupes électrogènes alimentés au diesel, sert à l'éclairage, aux appareils ménagers et aux outils électriques, mais rarement au chauffage des locaux.

L'étude conclut qu'à une charge de 100 % des groupes électrogènes diesel de la collectivité, la récupération de la chaleur pourrait entraîner des économies de mazout équivalant à quelque 110 000 $ par an. Les coûts du système de récupération de la chaleur et de la distribution sont estimés à quelque 400 000 $. Les consommateurs payeraient entre 14 $ et 100 $ le million de BTU, selon la distance qui les sépare du système.

L'autre source d'énergie qui semble viable est une petite centrale hydro-électrique. Une étude conceptuelle et un devis sont fournis pour quatre sites éventuels sur le ruisseau Pine. Le coût pour la collectivité d'acheter à la B.C. Hydro l'électricité produite par diesel au tarif subventionné de 5,66 ¢/kW.h est inférieur au coût estimatif de l'énergie produite par l'un ou l'autre des deux sites hydro-électriques les plus prometteurs (6,0 et 6,5 ¢/kW.h). Cependant, puisque les résidents d'Atlin s'attendent à des tarifs plus élevés applicables aux achats d'électricité dans l'avenir, l'idée d'accroître leur autonomie énergétique par l'exploitation de leur propre petite centrale hydro-électrique est attrayante.

Un certain nombre d'autres options pour remplacer le pétrole ne sont pas jugées faisables. Elles comprennent: le gaz naturel, le charbon, les sources géothermiques, le chauffage solaire, l'énergie éolienne et la tourbe.

L'étude a été menée pour l'Atlin Advisory Planning Commission par la Reid Crowther and Partners Limited à l'aide d'une contribution du Programme de démonstration dans les collectivités éloignées d'Énergie, Mines et Ressources Canada.

1.0 INTRODUCTION

1.1 PREAMBLE

In the spring of 1982, the Federal Department of Energy, Mines and Resources, Remote Community Demonstration Program, embarked on an energy conservation and renewable energy program for remote communities in Canada. The principal objective of the Remote Community Demonstration Program (RCDP) is to promote an awareness in remote communities of off-oil opportunities consisting of both economical demand management and reduction measures as well as viable energy supply alternatives.

The types of studies which receive consideration through RCDP, must identify and assess off-oil options available to remote communities in the context of specific energy technologies, conservation measures, supply options and projects which may be considered under Phase II of the program. The goal of this study is to identify the various forms of energy technology, conservation practices, supply options and viable energy alternatives available to the residents of Atlin, British Columbia.

In recent times the number of year round residents in the Atlin area has grown from about 75 in 1960, to a present day high of 342. Approximately 60 of these individuals are native, most of whom reside in the small Tlingit reserve at the south end of town. The Atlin population increases by about 125 each summer as seasonal residents return. If the growth rate continues at two percent per year, the year round population of Atlin will reach 479 by the year 2001 A.D. During the last twenty-four year period there has been a gradual growth in tourism, a rejuvenation of placer mining and an increased interest in pioneer lifestyles.

Housing in Atlin tends to be either older wood frame buildings that have been renovated and improved or log homes constructed within the past twenty years. Although Atlin is largely characterized by a cash economy and

specialization of labour, there are strong elements of a non-cash economic system present in the town. A large percentage of the population pursues a way of life that requires a much higher level of self-sufficiency than the national average.

1.2 STUDY OBJECTIVES

The British Columbia Ministry of Municipal Affairs is responsible for governing Atlin with an advisory role being played by the Atlin Advisory Planning Commission (AAPC). This study was completed for the AAPC through funding provided by the Department of Energy, Mines and Resources (EMR). The objectives of the study were to:

- o identify how energy is currently being utilized in the community;
- o identify other energy alternatives;
- o explore waste heat recovery opportnities from existing diesel; and
- o review the available B.C. Hydro studies on Pine Creek.

1.3 SCOPE OF STUDY

The overall scope of the study was to try and identify which type of energy alternative would provide the greatest long term benefit for the entire community of Atlin. Using a systematic approach, Reid Crowther first identified how energy is currently being utilized and then explored the various types of alternate energy which might assist in either conserving heat energy, or reducing the rate of oil consumption in the community. The intent of the study was to compare the two most viable energy alternatives in terms of cost and long term benefit to the residents of Atlin. Upon completion of Phase I, the community could be eligible for additional funding from Energy, Mines and Resources.

The scope of a Phase II program would be to actually implement initiatives discussed in Phase I. This would assist in satisfying Atlin's needs; it would also demonstrate a viable form of energy conservation and/or dramatically reduce Atlin's dependency on imported diesel oil.

1.4 METHODOLOGY

The first phase of the study was to identify how energy is currently being utilized in the community. In order to complete this task the Atlin Advisory Planning Commission (AAPC) identified a local energy auditing committee (EAC). This energy committee under the direction of Reid Crowther, assisted in determining how energy is presently being used in the Atlin area. To accomplish this objective Reid Crowther, in consultation with the auditing committee, developed an energy survey sheet. The first section of the data sheet (Appendix I) was aimed at updating information on the number and size of buildings; types of dwellings; and types and rates of energy consumption. The survey sheet also attempted to find out the maximum price and distance Atlin residents would be willing to travel for fuelwood. The questionnaire further asked Atlin residents what they perceived would be the <u>most important</u> energy source by the year 2001? Included in Chapter 4 and 5 of this report, is an analysis of the survey data and suggestions about the types of conservation measures that could be implemented.

The study also identifies Atlin's energy alternatives by assessing the region's longterm fuelwood, geothermal, solar, wind, peat, natural gas, coal and hydro potential. In addition, the report discusses the possibility of recovering waste heat from the existing diesel generators and re-establishing a small scale hydro project on Pine Creek.

The second phase of the study is to analyze all energy conservation and renewable energy information. This would be completed by identifying all viable energy alternatives; determining the different types of costs (i.e.

developmental, environmental) associated with different types of implementation; and, comparing the two most feasible energy alternatives in terms of capital costs, long term benefits and energy savings. Through ongoing consultation with the community, Reid Crowther determined the most beneficial, long term energy alternative for Atlin residents.

2.0 STUDY AREA DESCRIPTION

Atlin is located in the northwest corner of British Columbia (Figure 1) on the east shore of Atlin Lake, the largest natural lake in the province. The Atlin Lake Storage Project, British Columbia and Yukon, (Reid Crowther & Partners, 1983), describes the lake as being surrounded on the west side by the Boundary Range of the Coast Mountains, the Tagish Highlands to the north and on the east by the Yukon Plateau. A warm springs is located on the Warm Bay road approximately 20 km southeast of Atlin (Figure 2). Mixed pine, spruce and aspen forest dominate the area which has a continental climate.

2.1 LOCATION

Atlin lies 45 km (28 miles) south of the Yukon Territory Border, 192 km (120 miles) south of Whitehorse, Yukon and 1352 km (840 miles) north of Vancouver, B.C. (Figure 1).

A single gravel transportation link, the Atlin Road runs south to Atlin 98 km (60 miles) from Jakes Corner on the Alaska Highway in the Yukon. The town lies on the shores of Atlin Lake, one of the most southerly lakes in the headwaters of the 2000 mile long Yukon River Drainage Basin. This lake drains east through Graham inlet to Tagish Lake and continues north into Marsh Lake and mainstream Yukon River.

2.2 HISTORICAL DEVELOPMENT

Historically, fur trading, hunting, mining and tourism have been the chief factors leading to development of Atlin and surrounding areas. Of these, mining has had, by far, the greatest impact. The 1898 Pine Creek gold discovery set off the boom and bust cycle so common to northern mining communities. By the end of 1898 over 3,000 persons had visited the area.

FIGURE 1 REFERENCE MAP OF THE ATLIN STUDY AREA IN NORTHWESTERN BRITISH COLUMBIA

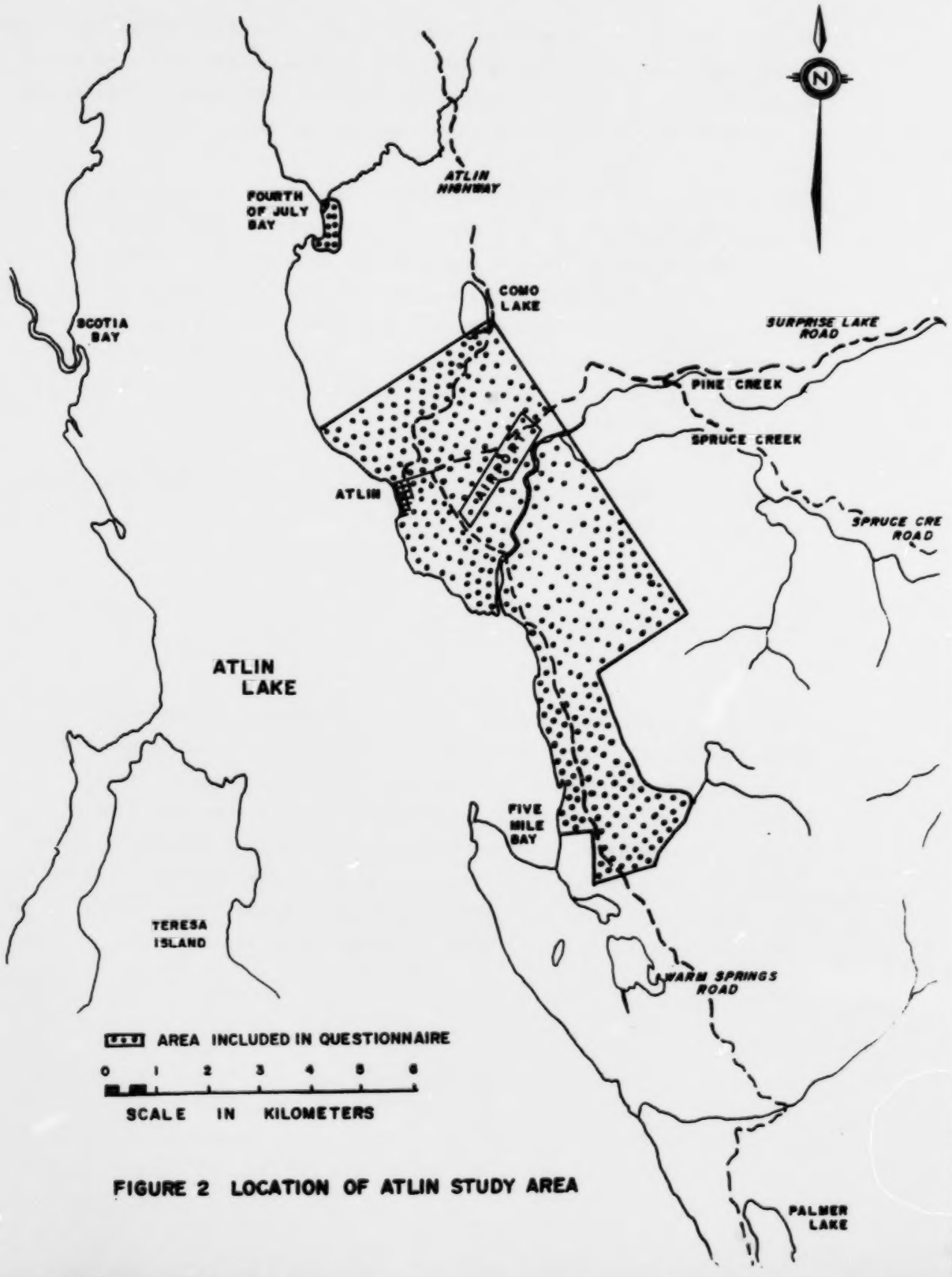


FIGURE 2 LOCATION OF ATLIN STUDY AREA

By 1910, the population was back down to 1,000. The first World War further diminished population. During the 1930's an even larger influx of gold seekers increased the population in the area to 5,000 people. During the Second World War Atlin's population steadily declined.

With the exception of the Ruffner silver mine, deposits of silver, lead and tungsten found in the region, have not proven viable. Transportation has always been a problem for business ventures in Atlin (Atlin, 1898-1910: The Story of a Gold Boom, 1971). Conversely the continual lack of a high speed transportation route to the community has ensured a degree of peace and stability lost to much of the outside world in the last 30 years. Little has changed in Atlin since the latest influx of modern age pioneers into the area in the mid '60's.

Hunting and trapping continue on a similar scale to the past with tourism gaining popularity annually.

2.3 ATLIN TODAY

Still largely undeveloped, Atlin today is a peaceful community of approximately 229 full time residents. About another 321 people live in the surrounding areas outside the town core. The area seems to attract independent and strong minded individuals, many of whom have created alternate lifestyles. Work exchange rather than cash payment is common among residents who exhibit a high degree of self sufficiency. As well, many people have developed several marketable skills. As a result of these and other factors, a strong sense of community exists in Atlin.

2.3.1 Demographic Characteristics

The total population of Atlin and surrounding area is approximately 550 in the summer, with about 60 being native, according to Stanley & Associates Atlin Community Impact Assessment (April 1981). Of this number, 229 people live in the town core (Statistics Canada 1981). Summer residents swell the community by about 100-150 every year. (Stanley and Associates 1981). Approximately 33% of the year round population is 19 years of age and under; 38% are 20-39 years old; 17% are in the 40-59 year age bracket and 11% are over 60. In proportion to the Yukon population, there are more elderly and fewer children here. (Stanley and Associates 1981). The stable group of residents is due to mining activity and/or lifestyle preference increasing the latter.

2.3.2 Housing

Primarily, Atlin housing can be divided into two types: older frame buildings dominate the community's centre and log structures are most common in areas peripheral to the town core itself. Of the 122 housing units in Atlin covered by this survey, 80 are occupied by a total number of 225 people. (Statistics Canada 1981). Over 80% of the single family dwelling units are owned by the occupants.

A breakdown of these units follows:

single detached:	65
house attached to a non-residential building "moveable" buildings i.e. tent, travel trailer;	5
car, houseboat	5
mobile homes	5

2.3.3 Economy - Present

The economy of Atlin can be broken down into three main components.

1. Activities which generate a flow of dollars from outside the area, mainly from the government, mining and tourism sectors.
2. Activities which recycle dollars within the area including those of a local goods and services nature.
3. Activities of a non-cash nature which include self sufficiency activities and those involving barter.

The Atlin Official Community Plan (October, 1981) identified ten percent of the workforce to be government employees, thirty percent were employed in the commercial (goods and services) sector and forty seven percent were self employed primarily in the tourism and construction sectors. This high percentage of self employed individuals reflects the "Atlin lifestyle" and many of these participate in self sufficiency activities as do, albeit to a lesser degree, many people involved in the other employment sectors. One could conclude that while many business opportunities probably exist in the Atlin area, its residents have been content to participate in employment which is of direct benefit to the community as a whole and to their individual lifestyles.

2.4 ATLIN TOMORROW

There are two possible scenerios for Atlin's future. If world market metal prices increase, the mining and exploration activity in the area would pick up. The attendent swell in population would place an increased demand on the type and quality of services and facilities presently available. As well, there would be greater use of the infrastructure now in place, leading to more activity in the construction and other trades.

This possibility could mean more long term residents, as well as a surge of seasonal visitors to the community. However, should the economy remain at its current level, then Atlin would probably continue its present rate of growth, with no major changes.

2.4.1 Demographic Change

The population of Atlin has fluctuated over the past 40 years (Figure 3) making forecasting future population difficult. An upswing in the number of residents has been followed by a downswing. Today's population reflects that trend, there being 21 people less in 1981 than in 1976, according to Statistics Canada 1981 figures. If the current rate of inward-migration of 25 individuals per year continues, and present types of employment opportunities do not expand, Atlin could have a year round population of approximately 1000 people by the year 2001.

method: 25 (inward-migration x 17 years (1984-2001 A.D.) per year) = 425 people
425 (future population) + 550 (present population) = 975 people

If the inward-migration population is ignored or assuming that it equals the outward migration, the only population increase or decrease to be experienced in Atlin area, would be regulated by the birth rate. Figure 4 outlines a number of population scenarios which may result by the year 2001. If in 1984 Atlin has a population of 342 (based on 122 residents realized from the 1984 questionnaire and the 1981 Stats Canada estimate of 2.8 persons per household) then a minus 2% per year population growth would result in 243 persons by the year 2001. A plus 2% population would result in 479 persons, a plus 4% in 641 persons and finally an unlikely plus 10% growth in 1729 persons.

Appendix II - Figure 17 is a projected population estimate for the year 2001 using Statistic Canada's 1981 population of Atlin. The Atlin Advisory Committee during one of the community presentations felt this 1981 figure of 229 residents was low. This Appendix is therefore, included for reader's perusal only.

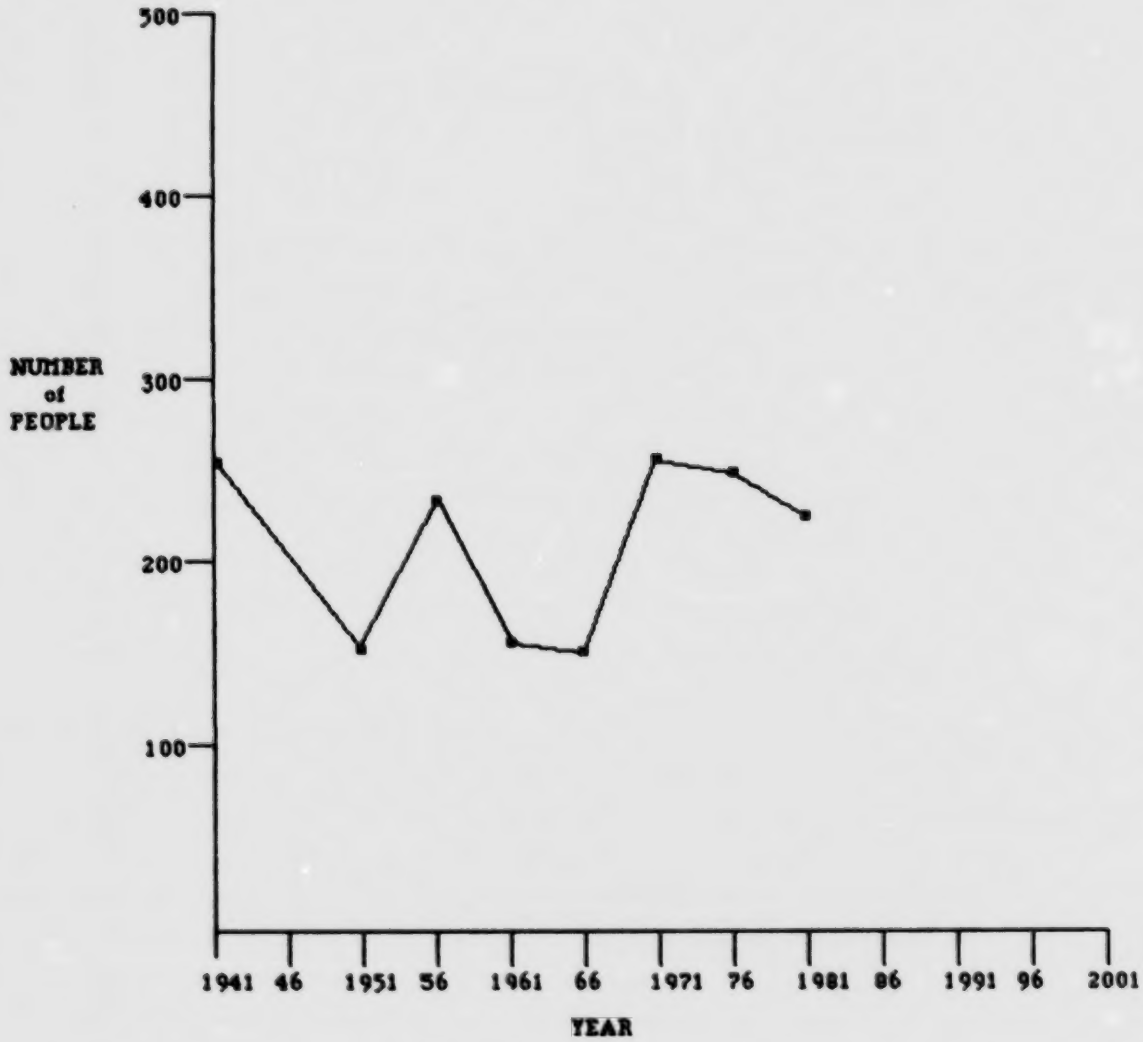


Figure 3 - Atlin Population Change 1941- 1981

Source: Statistics Canada Census Data. 1941-1981. Ottawa.

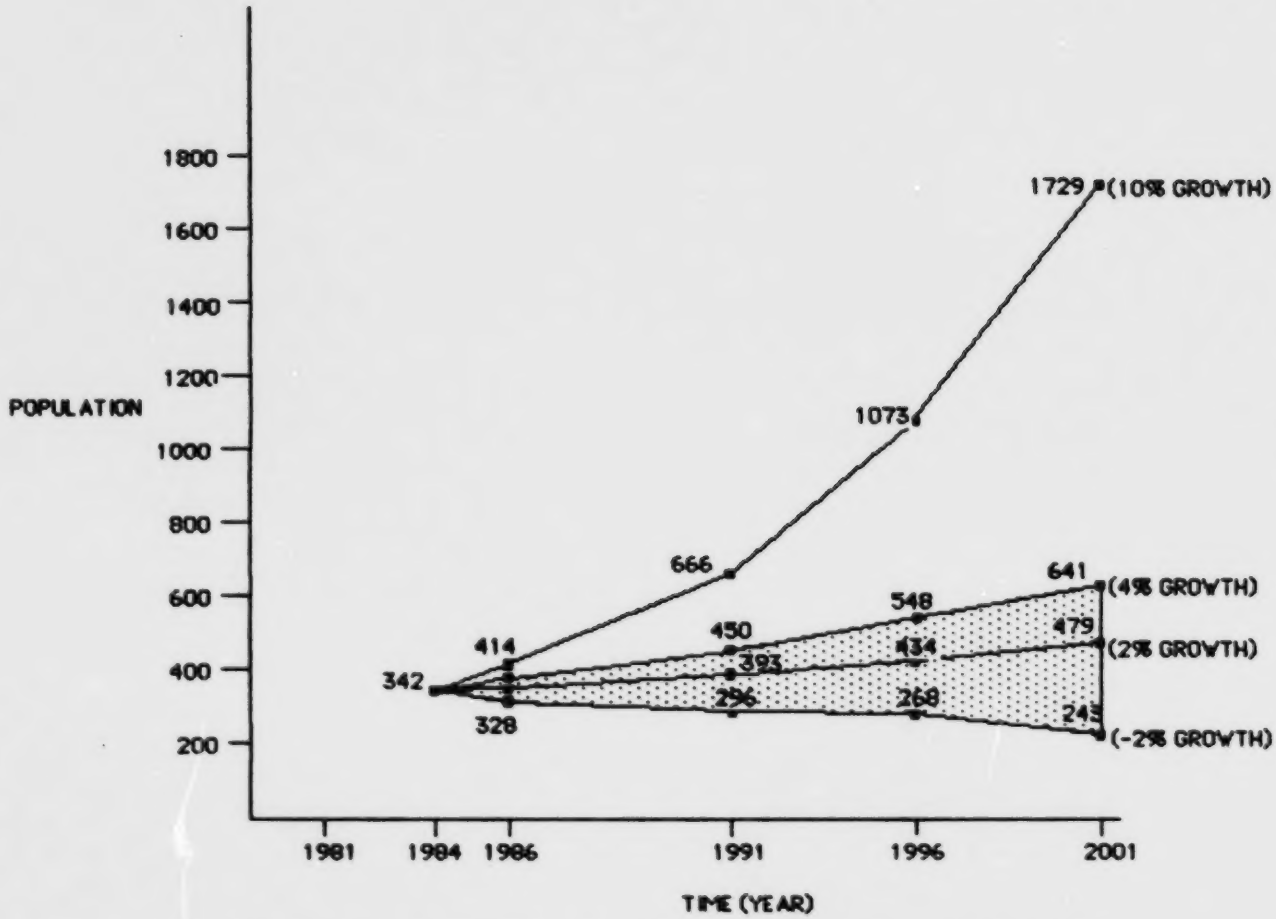


Figure 4 - Projected Populations in the Year 2001 in Atlin (122 residents from 1984 questionnaire and 2.8 persons per residence - Statistics Canada 1981 Year Book)

A projection in the Atlin Official Community Plan (Oct. 1981) had anticipated a population of 700 by 1985. As well, an increase of an additional 800 people was forecast with the opening of the proposed Adanac molybdenum mine. However, the mine is not likely to open in the near future. Until economic activity picks up, Atlin's population will probably follow historic fluctuating trends.

2.4.2 Housing Needs

Statistics Canada lists the average size family in Atlin as 2.8. With a predicted population increase by 2001 A.D. (refer to Figure 4), there could be a need for approximately 143 new homes, or 9 houses per year. Given, there being a number of rental houses available, the figure could be lower. Demand for housing would increase if development of the Adanac mine was to proceed. A need for approximately 405 dwelling units to accomodate the influx of mine workers has been forecast in the Atlin Official Community Plan (Oct. 1981). The report further states that units selected would probably be row housing or apartment, because of different needs and desires of potential mine employees. Both types of accomodation would require sewer and water.

2.4.3 Economic Future

Atlin's economic potential for the future lies mainly in the areas of government, mining and tourism.

Should government services to the area expand, there would be a net inflow of dollars as the Atlin tax base is not large enough to support many of these new services such as water and sewer, recreation and highway upgrading. While growth in this area may be slow, it would certainly help to expand and stabilize the population base.

Mining activity in this area is largely dependent on natural resource prices, mainly for gold and molybdenum. These prices are at the mercy of world markets and are not expected to rise significantly in the near future. Should prices increase however, there would be an increase in mining and exploration activity. Placer mining activity would pick up quickly and large projects such as the proposed Adanac molybdenum mine would be more viable. This increase in activity would broaden Atlin's economic base substantially.

It is in the area of tourism that Atlin can achieve its greatest inroads while maintaining control over growth and development. There are currently a small number of tourism oriented businesses operating in the Atlin area, but by and large there appears to be no concerted effort to generate more tourist activity. The newly formed Atlin Visitors Association is a step in the right direction and it will hopefully help to effectively promote Atlin as a unique destination area in both summer and winter.

3.0 ENERGY INVENTORY

3.1 INTRODUCTION

The purpose of this section of the report is to identify and assess the relative costs, limitations and advantages of the full range of energy alternatives available for Atlin. Information contained in this inventory is derived from existing data, literature sources and through personal communications with local Atlin residents.

The energy inventory is separated into eleven different categories. Each category refers specifically to existing information on each energy alternative for the community. Conclusions are drawn regarding the overall viability of each of these alternatives. Viable energy alternatives are discussed in greater detail in Chapter 6.

3.2 ENERGY SOURCES

Atlin energy requirements are largely met by utilizing refined petroleum products. Wood and propane are also recognized as important energy forms. Other alternate energy sources which are currently being examined include coal, peat, wind, geothermal, small scale hydro and waste diesel. The viability of each of these energy alternatives is assessed in the following subsections.

3.2.1 Wood

Wood has traditionally been used as a heating fuel in the Atlin area. It is generally understood that the more remote a community is, the greater the

cost advantage, since the cost of wood usually declines with distance from a major centre relative to the cost of alternate fuels. Atlin residents either purchase or cut their own wood and the majority of it is seasoned as opposed to fire-killed. Wood waste conversion for energy used to generate power and for heat is also being developed. The only way this type of operation can be cost effective relative to oil is if there is a concentrated supply of fuel and an efficient means of handling the fuel (Sigma Engineering, 1983). These systems are usually large scale and exceed the burning requirements of most remote communities. The biggest unknown in any wood waste system appears to be the cost of gathering the fuel source (Sigma Engineering, 1983; Baxter, 1983). One variable which has not been addressed is the overall level of air pollution produced by such large scale facilities. In any area prone to temperature inversions, this could be a definite health hazard.

Atlin residents currently burn an estimated 700 cords of wood per year. Assuming that the volume of each cord of wood is 3.6 m^3, the overall volume of wood burned in 1983 was approximately 2500 m^3. Unfortunately this value does not take into account that perhaps as much as 30 percent of each cord of wood is actually airspace; however, for the purposes of this study we will use this higher estimate of 2500m^3.

The British Columbia Forest Service estimates (July 4/84 S. Armitage, pers. com.) that within a 40 km (25 mile) radius of Atlin, there is 4.76 million m^3 of useable timber (S. Armitage pers. com.). The British Columbia Forest Service also estimated that to maintain a 2500 m^3 yield would require 5000 hectares; assuming an annual growth rate of 2 m^3 per hectare. At this rate, Atlin residents based on their 1983 consumption rate, could continue to harvest fuelwood for 1090 years.

One important question raised at the first of two community workshops (Appendix III) was; "how much wood is used for alternate uses"? There are currently six sawmills operating in the Atlin area (July 4/84 pers. com). In an average year it is estimated that 2500 m^3 is harvested. If this value is added to the current fuelwood harvest rate, the Atlin vicinity

could continue to supply both needs for 545 years. To sustain an annual cut of 5000 m^3 would require approximately 10,000 hectares. The principle species would include spruce as well as pine, alpine fir and aspen (S. Armitage, pers. com).

If the population of Atlin grows at a rate of two percent per year, the fuelwood demand by the year 2001 will be significantly higher. Assuming a base population of 342 year round residents in 1984 (Figure 4), the estimated population by 2001 will be 479. The average number of residents per household is currently 2.8 (Statistics Canada, 1981). Recent survey estimates indicate that 67.8% of all Atlin residents rely on wood heat as their primary source of heat energy. By the year 2001 there will be an estimated 171 households in Atlin. If each of these residences burn an estimated average of six cords per year this will bring the annual consumption rate to 696 cords. Assuming that each cord is still 3.6 m^3 this could mean an increase in the annual harvest to 2505 m^3 of wood per year. If this value was doubled in order to take into account increased in other types of wood use, the annual harvest by 2001 A.D. would be estimated at 5,011 m^3. At this rate of wood consumption (assuming an annual growth rate of 2 m^3 per hectare) it is estimated that Atlin could maintain a sustained yiedl for 545 years.

significantly less than all other energy costs (Table 1); however this does not take into account the costs associated with hauling, stacking, splitting, cleaning or purchasing a wood heater. Given the highly self sufficient life style of most Atlin residents and the life expectancy of the forest supply, it is highly unlikely that fuelwood would be replaced, as the most important primary form of residental heat energy.

3.2.2 Refined Petroleum Products

Refined petroleum products are brought into Atlin by truck by the Alaska Highway and Atlin Road. These products which are supplied primarily from

TABLE 1

ENERGY EQUIVALENT COSTS

Source	Unit	Unit Cost	Approximate Unit Energy Cost (Per million Btu)	Extraction Efficiency*1	Actual Energy Cost (Per million Btu)
Firewood	Cord	$60.00	$ 3.53	60% Airtights	$ 5.88
Home Heating Oil	Litre	$ .462	$ 13.02	60%	$ 21.70
Hydro Electric	kW.h	$ .17	$ 49.81	100%	$ 49.81
Electricity (Actual cost-1983)	kW.h	$ .457	$133.31	100%	$133.31
Electricity *2 (Subsidized cost-1984)	kW.h	$ .0566	$ 16.60	100%	$ 16.60
Propane	Per 100 lbs	$44.00	$ 20.00	70%	$ 28.50
Diesel	Litre	$ .463	$ 13.04	60%	$ 21.74
Gasoline	Litre	$ .611	$ 17.22	20% Auto	$ 86.10
Coal Oil	Litre	$ .909	N/A	N/A	N/A
Kerosene	Litre	$ .909	$ 25.60	90% Kerosene	$ 26.13
Electricity (Gas Generator)	kW.h	$ .611	$ 17.22	16%	$107.62

*1 allowance made for fouling effects over time
*2 for the first block of the 1984 rate structure

Table 2

Estimated Primary Demand for Refined Petroleum Products

Sector	Refined Petroleum Product's Share of Total Sectoral Demand	Major End Uses
Residential	30%	Space and water heating
Commercial	56%	Heating and cooling
Industrial	100%	Process heat
Electric Power Industry	100%	Diesel generation
Transportation	100%	Auto, truck, air

In terms of potential uses, refined petroleum products are unsurpassed; however, given their location and high cost, the long range feasibility of this type of energy is in doubt.

The energy equivalent cost per million Btu of each type of refined petroleum product is provided in Table 1. The most cost effective utilization of any refined petroleum product in Atlin, is home heating oil ($21.70). Heating oil is the second most important type of space and water heating (Figure 10). This picture changes however when the cost of subsidized electrical generation is considered. When the actual cost of diesel oil-fired electrical generation is taken into account, residential heating utilizing electrical heat generation becomes much more cost prohibitive. The actual cost of diesel fuel is almost as efficient as home heating oil (assuming an extract efficiency of 60%). Kerosene and propane are also reasonably efficient and cost effective petroleum alternatives. Gasoline remains one of the most inefficient forms of energy consumption and is largely utilized in the transportation sector.

Whitehorse, Yukon are used for heating, transportation and electric power generation. Atlin's dependence on refined petroleum products is very similar to Yukon. A study completed in Yukon (Hodge, 1982) estimated the total sectoral demand of refined petroleum products. The modified estimates for Atlin using Hodge's format, are provided in Table 2.

3.2.3 Diesel Electric

B.C. Hydro's billing is on a block rate structure format based on energy use. The first block rate is $.0566/kW.h. The second block rate is .0378/kW.h. This means that the actual "subsidy" may be higher depending on the consumer's level of energy use. The majority of Atlin residents rely on diesel generated electricity. The bulk of the current residential demand is for operation of peripherals such as lights, appliances and power tools. During the first community meeting Atlin residents indicated that very few individuals actually rely on electricity as a primary source for space heating. The actual cost per million Btu to produce this energy is $133.31 (Table 1) although the subsidized rate is $16.60 (based on the first block rate structure). The high unit cost per kW.h is primarily a direct result of the high price of diesel fuel. There does not appear to be any foreseeable mechanism available to assist in reducing this cost. The only available avenue to assist in reducing costs is through energy conservation (waste heat recovery).

3.2.4. Hydro Electric

Pine Creek hydro electric power is first cited in the literature in 1903. Original uses were for placer mining related work with the power plant located a short distance below the falls. The power house employed two 24 inch, 500 horsepower turbines. These units could be operated either separately or together.

Completion date of the British American Dredging Co. Ltd. owned power plant, was the end of the 1903 mining season for first use during 1904. Almost immediately, power was being sold to other mining companies for their steam shovels. The power plant continued to operate, whether or not the renamed owners, the British Columbia Electric Mining Company placer mined.

The electrical capabilities of this first hydro plant was 1,100 volts which was increased for transmission and reduced for use on the dredges. The generating plant used only one turbine at a time for producing electrical energy; one other turbine was maintained in a state of readiness to provide a back-up system.
Water was originally taken from above Pine Creek Falls and delivered via a conveyance ditch to a pressure box, 187 feet above the turbine. By the time the Hydro Plant was abandoned in the 1940's, control structures at the outlet of Surprise Lake were capable of increasing water levels an additional 7 feet in order to meet requirements for hydraulic sluicing and power generation near the town site of Discovery.

In 1956, a study was undertaken for the B.C. Power Commission covering aspects of village electrification. The Noland mine power plant was considered a possibility, but was discounted because of the poor condition of both the machinery and the canal.

The Noland mine hydro plant was closed down in 1957 and the machinery was left unattended. No details as to the construction data were found. During the operating life, difficulties were experienced with icing in the canal, and it appears that mining was curtailed during the severe winter months.

Voiced energy concerns in 1973 initiated a reassement of hydro electric generation possibilities by B.C. Hydro and Power authorities. In a February 1977 report released by B.C. Hydro, concerns and possible solutions were itemized. Alternate electric energy sources included:

1. Construction of a dam on the Atlin River, 3 miles across the lake from the town;

2. Supply of power from Whitehorse by N.C.P.C.; and

3. Pine Creek hydro project redevelopment.

Once the concerns of Atlin residents and the natural concerns such as frazil ice had been addressed, the need for an installation including a 1000 kW unit combined with a standby diesel system was identified.

In 1980, a large scale conceptual study was completed for the Pine Creek watershed. This scheme proposed the construction of a 30 metre high dam at the west end of Surprise Lake, with a power canal leading to a point overlooking Atlin Lake south of the Village. The order of magnitude was 6000 kW. Again, the scale of this scheme is beyond the scope of present needs. Additional evaluation studies by B.C. Hydro have been completed, or are on going, for the Atlin area. However, current accounting system at B.C. Hydro require a payback period of no longer than five years. This does restrain B.C. Hydro from moving toward smaller scale electrical generation which requires a longer pay back horizon.

Presently, the concerns of the community remain the same as in the past, but because of interest in future energy self sufficiency, Atlin residents favour small scale hydro even though short term foreseeable increments in prices would result.

3.2.5 Propane

Numerous petroleum resource areas exist in northern British Columbia and Yukon Teritory. The closest of these areas to Atlin are considered "Dry" (contain methane and ethane, but little or no propane).

Propane transportation into Atlin is considered to be against the flow. The small quantities consumed by the Atlin residents are first transported by the Alaska Highway to storage facilities in Whitehorse before again being transported down the Atlin Road.

Propane use in the Atlin area presently has only marginal importance as a primary energy source, but is of much greater importance as a secondary or tertiary source, especially for those who do not live on an electrical grid. As problems caused by cost and cold weather are overcome, propane is also becoming a viable energy alternative for vehicle use.

3.2.6 Natural Gas

Natural gas, if and when available in Yukon and northwestern British Columbia could be used as an energy source for power generation, heating and transportation.

Potential sources of natural gas presently are dependent on construction of one or all of the proposed pipelines. The Alaska Highway Pipeline, the Dempster Lateral or proposed pipelines in western Northwest Territories are all possibilities from north of Atlin. There are natural gas fields in northern British Columbia presently in production, but populations and distance logistics to Atlin, cannot justify northward connections in the foreseeable future.

Of the various pipeline possibilities mentioned above, the Alaska Highway Pipeline would be the most attractive alternative.

3.2.7 Coal

Coal deposits are widely distributed in British Columbia. These deposits are confined to small areas and tend to be great distances from population centres as well as transportation lines.

Most large developed coal fields in British Columbia exist in the east and southeast section of the province. The extent of the coal fields of northern British Columbia is not known and due to the low rank of the coal and their inaccessibility, their significance is purely local (Coal Reserves of Canada, 1947).

3.2.8. Geothermal

Geothermal activity in the southern part of the Yukon Plateau (Northwestern British Columbia) is primarily in the form of thermal springs. The location of these springs is influenced by faulting. Water temperatures are usually between 9.5°C to 29°C with the warmest being the Atlin spring at Warm Bay.

Although the Atlin spring is easily accessible by road (20 km), all other springs must be reached by boat or float plane.

Thermal springs fall into 3 classes:

1. those related to deep flow systems in layered rock, predominantly carbonates;
2. those originating in fractured metamorphic or intrusive terranes; and
3. those occurring in and near areas of Quaternary volcanic activity.

Thermal springs in the Atlin area do not fall into Class 3 springs commonly associated with electric power generation. Therefore the Atlin springs could only be employed for space or process heat. In fact because of the extractable energy being so marginal (20 l/sec of water from the warm springs) the only use of the springs would be to augment the municipal water supply. The fact that the warm springs are 20 km south of Atlin eliminates even this alternative.

3.2.9 Solar

Decreased production costs of solar collectors are making their use more attractive in parts of southern Canadas where a high amount of solar energy is available. Users of these panels tend to be the residential sector who presently employ solar power for space and water heating and also for photovoltaic power (direct conversion of solar power to electricity) generation.

In northern Canada solar energy density tends to be low during high winter heating load requirements and the initial capital costs to produce significant amounts of energy are relatively high.

Solar radiation data in the vicinity is only collected at Whitehorse, Yukon and estimates or trends must be extrapolated to the Atlin area. On an annual basis the available solar energy does not appear to be sufficient enough to meet total community requirements and, therefore, the systems must be recognized only in a supplemental capacity to other energy sources. For this reason alone solar energy presently appears to be an uneconomic alternative.

3.2.10 Wind

A member of the Atlin community has been recording daily wind velocity and direction at 0700 hours and 1900 for the past decade (pers. com). Although the data is volumous, direct application towards wind generated power is almost impossible without a continuous 24 hour a day anemometer reading.

Generalization of the Atlin wind situation as with solar data must be extrapolated from Whitehorse, Yukon data. Wind velocity and direction are

similar to both communities in terms of valley configeration, north-south orientation and geographic location. Over the last number of years monthly averages of 14.1 km/hr have been recorded in Whitehorse with highs of 15 + km/hr occurring realized in the spring and fall. Lows of 12 km/hr in the middle of winter and summer are also included in the annual trend. The prevailing wind direction comes from the south to southeast year round.

Wind generating units available on the market presently, are capable of handling a wide variety of high output wind velocities depending on the requirements of geographical location. The small units have a cut-in wind velocity of 11 km/hr and velocity requirements increase proportionally with the size of the units. Assuming Atlin's anemometer reading being similar with those in Whitehorse then at best units of any capacity would not be economically viable at any time of the year in the region.

3.2.11 Peat

Peat is a very young and unpressurized predecessor to coal and is formed very slowly by the decay of moss. Although Canada is considered to have the second highest quality of peat in the world, associated permafrost areas in the north make conventional means of peat accessibility, preparation and harvest, more difficult.

Very little detailed inventory work or reserve estimates exist for northern areas although future work is planned. Present literature indicates southern Yukon and northern British Columbia have only sparse distributions of peat lands.

The limited distribution of peat and the lack of road access, reduce its potential as a significant energy source in the foreseeable future. Peat is not presently used as an energy source by any surveyed Atlin residents.

4.0 ENERGY USE IN ATLIN, B.C. (1984)

4.1 INTRODUCTION

An energy questionnaire was circulated to residents of Atlin, B.C. during May 1984 (Appendix I), in order to solicit a response about building size, type and construction and on individual energy consumption. The types of fuel sources reviewed included firewood, heating oil, electricity, propane, coal, diesel fuel, regular gasoline, coal oil and others. Residents were requested to identify both primary and secondary energy fuels and the average monthly consumption of each. Responses to maximum distance to wood supplies, price of cord wood and what residents considered to be the most important fuel in the year 2001 A.D. were also solicited.

A total of 143 responses to this questionnaire were received from the residents of Atlin. The results are discussed under the following sub sections and pictorally displayed in Figures 5-13. Accompanying each figure is the total number of responses received to each question. As in Figure 5, "Types of Building Occupancy", a single questionnaire return may have identified their respective building as having more than one use. Still the 143 questionnaires represent the 100%, not the 165 responses received by those 143 questionnairees. These slightly skewed results still represent the relative popularity of each selection.

The results from the questionnaire do not necessarily reflect the total number of buildings in the Atlin community. There is a high incidence of buildings that are abandoned, boarded up or for sale by absentee owners. Statistics from the Atlin Review Committee identified approximately 40 residences for sale.

Although the primary concern of this questionnaire was for energy uses only within the home, secondary information was obtained concerning total energy use oy Atlin residents within the transportation sector.

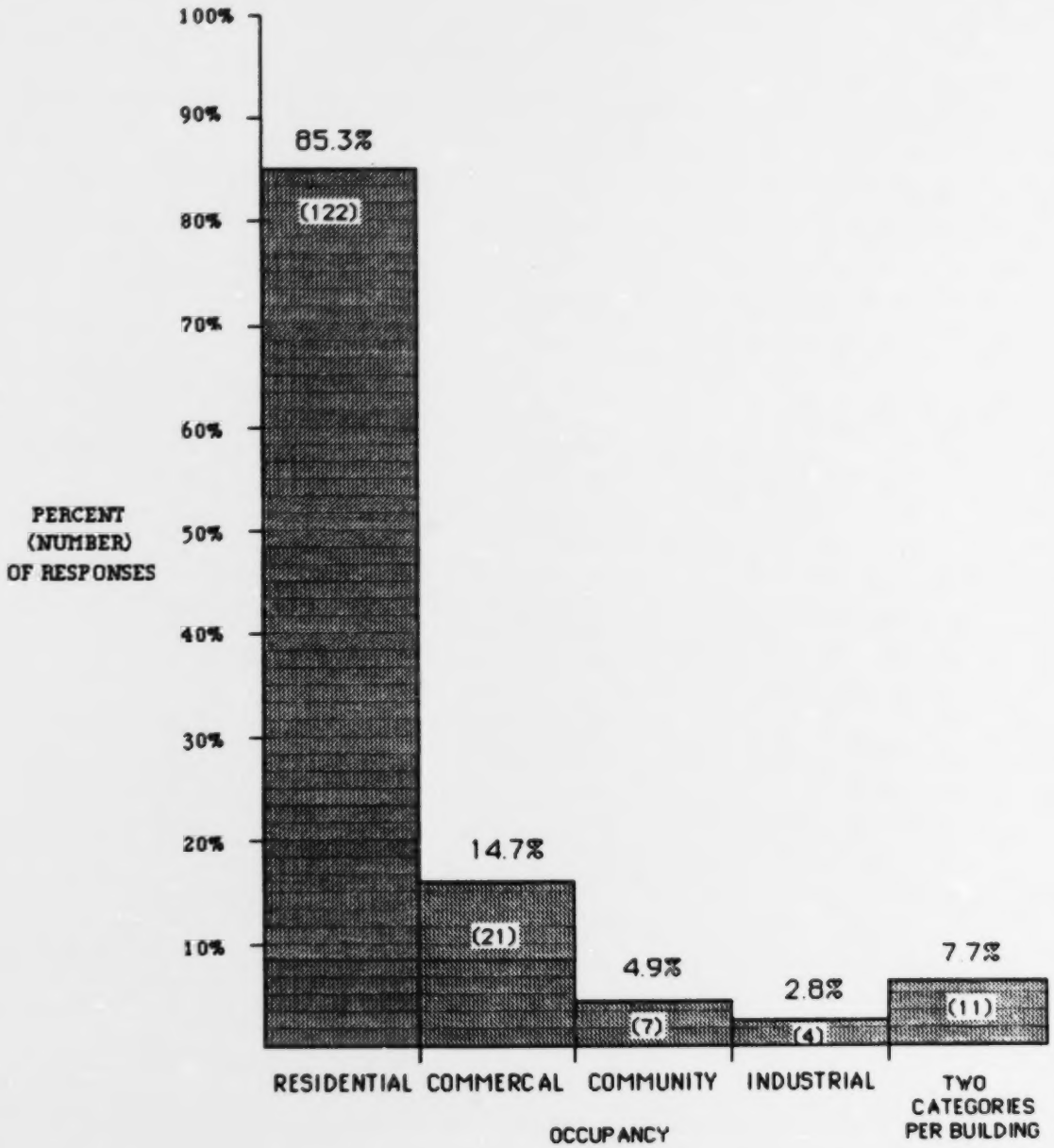


Figure 5 - Type of Building Occupancy
(143 questionnaires - 165 responses)

4.2 ENERGY ANALYSIS

Responses from the 143 questionnaire returns, categorized the various buildings within the study area by building occupancy. (Figure 5). One hundred and twenty two (85.3%) of the buildings were residential, 21 (14.7%) were commercial, 7 (4.9%) were community and 4 (2.8%) were classified industrial. Eleven returns identified their buildings as combination of two different categories.

The Atlin School, the Recreation Centre, the Anglican Church, the Heritage Building, the Red Cross Hospital, the Government office and the Royal Canadian Mounted Police office were considered community buildings during the survey.

Information gathered from the questionnaire, identifies that 119 (82.3%) buildings are occupied on an annual or year round basis, 15 (10.5%) buildings are occupied on a seasonal basis and the remaining 9 (6.3%) questionnaires, had no comment (Figure 6).

A review of materials used in construction of buildings in the Atlin area suggests that frame and log format are of equal popularity (Figure 7) with 66 (46.2%) of the questionnaires responding to each. Twelve (8.4%) lived in trailers or mobile homes, the final 2 (1.4%) had steel or aluminum buildings. Seven (4.9%) of Atlin's buildings in the questionnaire are a combination of two or more types of construction materials and an additional 4 (2.8%) of the questionnaires had no comments.

Electricity was identified to be used in more households than any other energy source (Figure 8). Although electricity is the most popular, its use tends not to be as a heating source, but instead for peripheral uses to run modern conveniences. One hundred and fifteen (80.4%) of the buildings in the questionnaire used electricity. Wood was the most popular heat energy source, being used in 113 (79%) household; oil being third with 49 (34.3%) users; fourth was propane with 46 (32%) users; and other categories including kerosene and solar had 10 (6.9%) users.

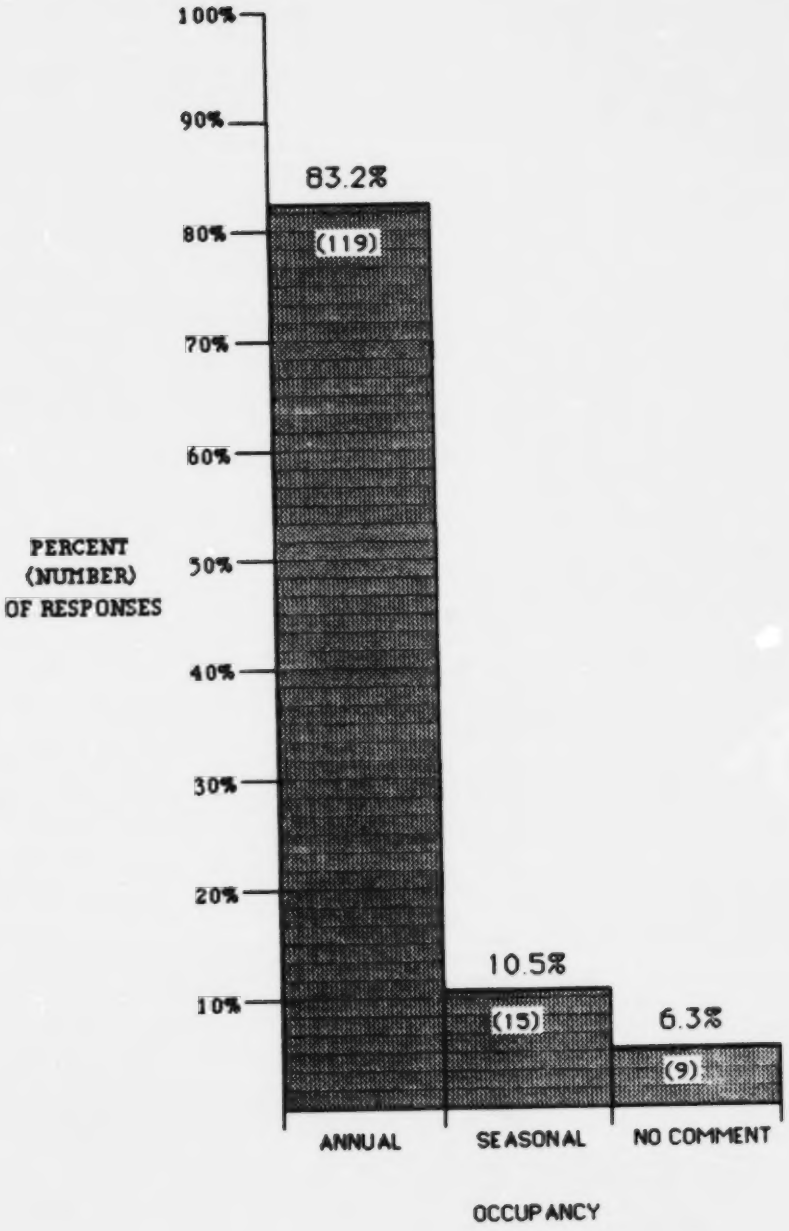


Figure 6 - Length of Annual Building Occupancy
(143 questionnaires - 143 responses)

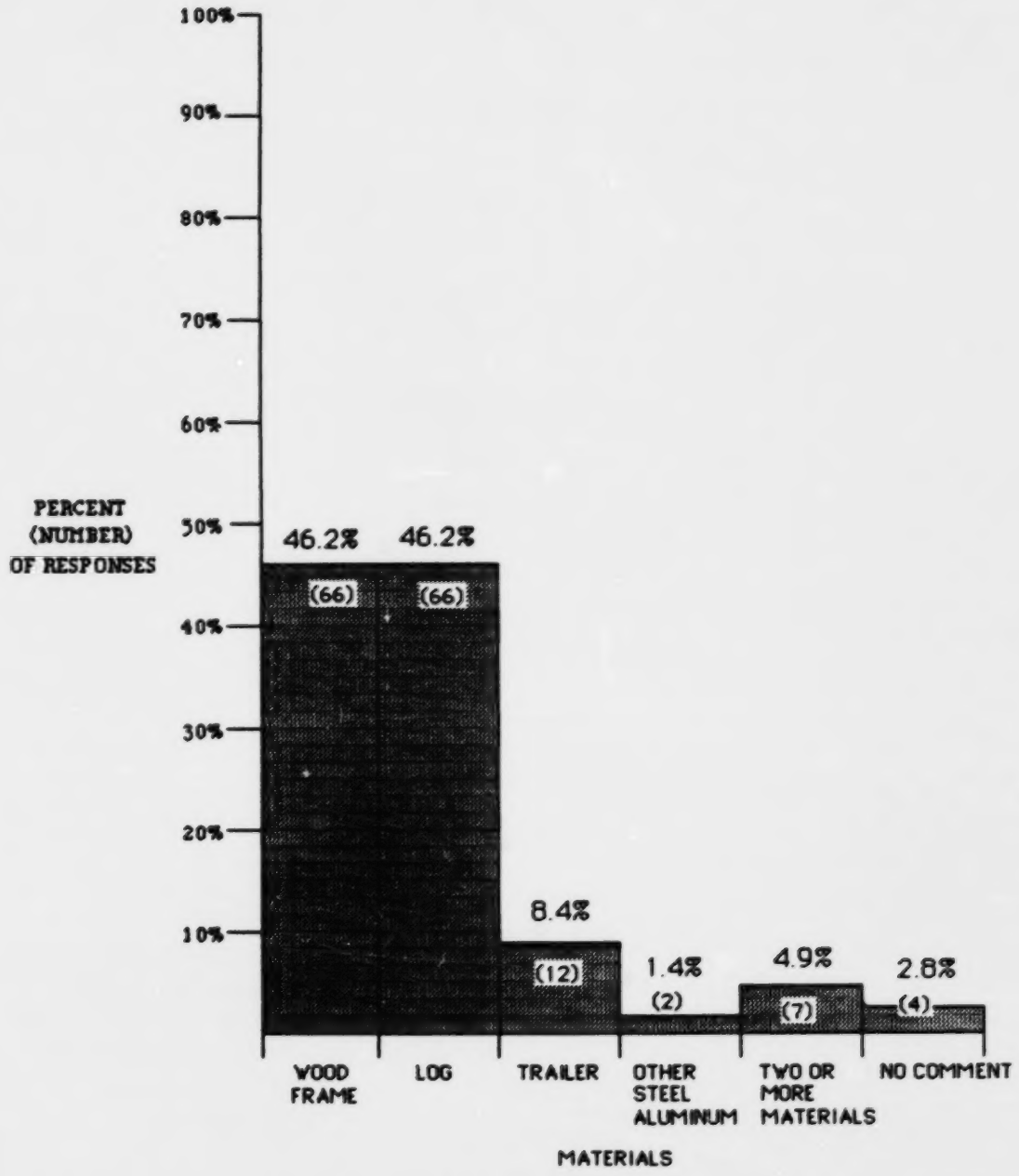


Figure 7 - Type of construction Materials used in Buildings
(143 questionnaires - 157 responses)

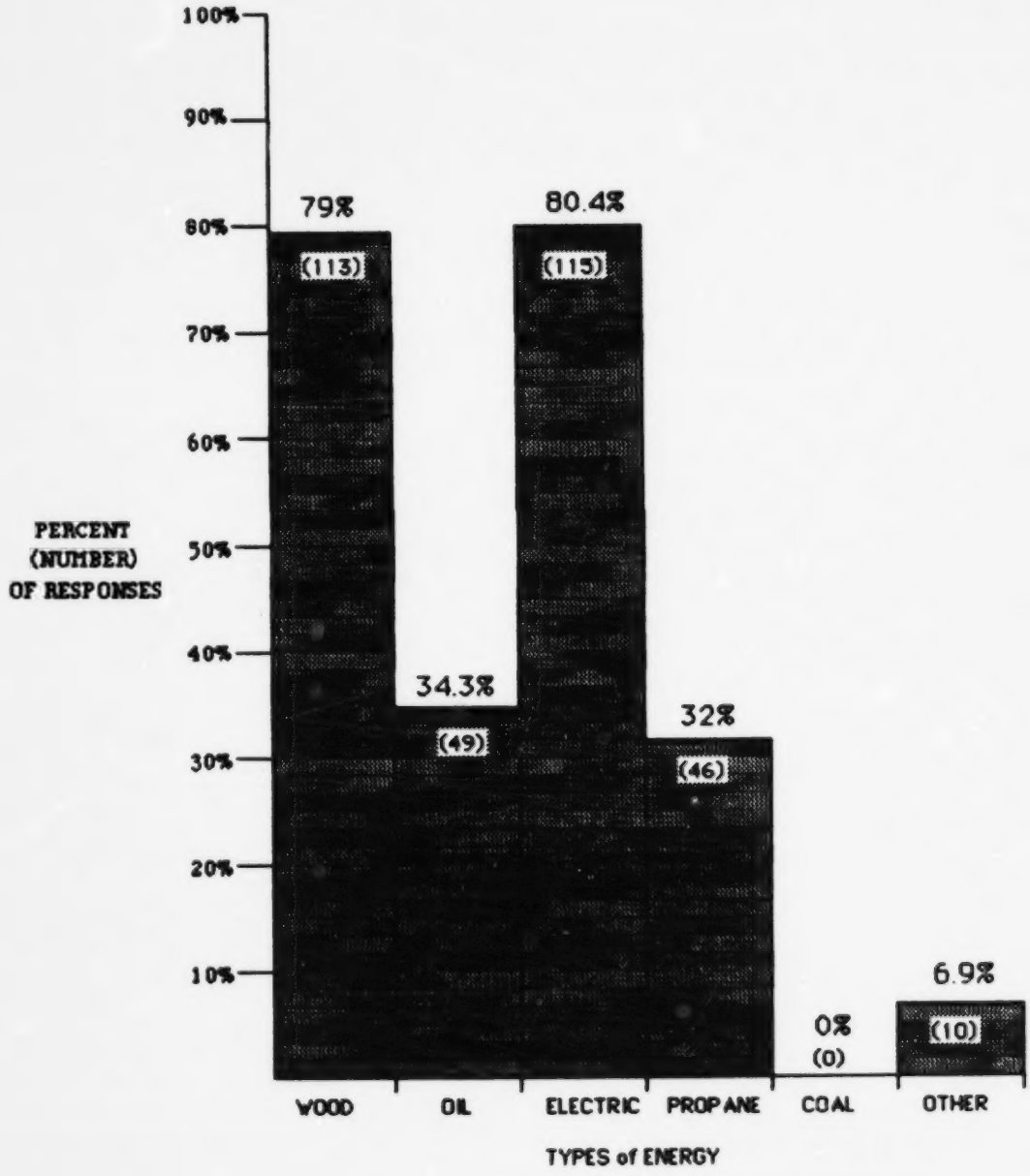


Figure 8 - Popularity of Energy Types *

(143 questionnaires - 323 responses)

*Approximately 94% of Atlin Community residents rely on more than one energy source.

Energy consumption by Atlin residents vary by sources and quantity from the 143 responses to the questionnaire, 8 (5.6%) identified only one energy source used per household. (Figure 9). An additional 83 responses (58.0%) identified two energy sources and the final 52 (36.4%) identified three or more energy sources being used within the buildings.

4.2.1 Firewood

A total of 113 (79%) of the 143 questionnaires returned used firewood as a source of heat energy. This represents Atlin's second most popular overall energy source (Figure 8). Of the 113 residents using wood, 97 did so as a primary heat source (Figure 10) and the remaining 16 users, in a secondary or back up capacity (Figure 11).

The 58.05 cords per month (697 cords per year) of firewood used by Atlin residents as obtained by 1984 questionnaire is usually obtained green and allowed to dry for one year prior to use. All cord wood is cut to length and used "as is" with no further alterations or processing. The dimension of a cord as used in this discussion, is the amount of wood required to fill a four foot by four foot by eight foot box (128 cubic feet or 3.6 cubic metres). This does not take into account the amount of air space between each log; however, for discussion purposes the optimum theoretical value of 3.6 cubic metres will be used.

One of the inquiries on the questionnaire was to find out the maximum price individuals would be willing to pay per cord of firewood. Results from the 143 responses varied between a low of $0.00 and a high of $130.00 per cord. Thirty residents do not use firewood, 23 residents would not pay for wood and the average price based on responses is $64.84 per cord.

When questioned about distances Atlin residents are prepared to travel to obtain firewood, 6 (4.2%) indicated less than 1 mile (Figure 12). Thirteen

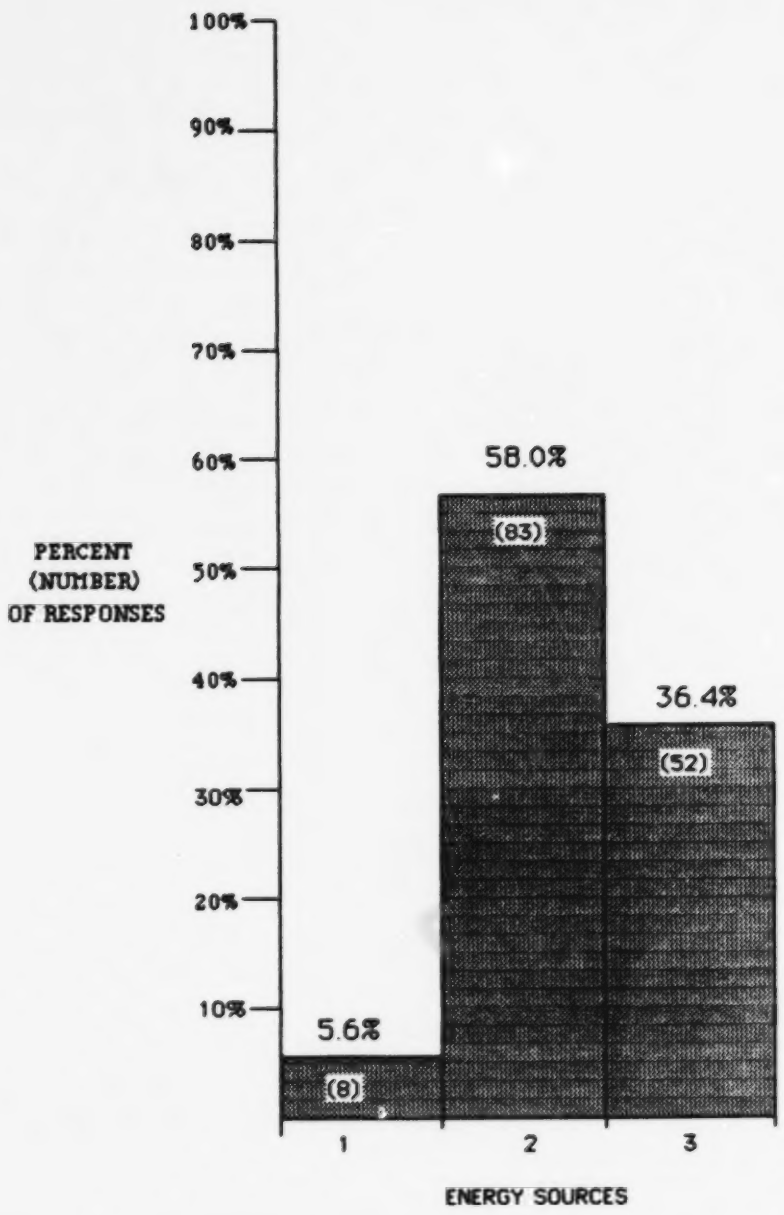


Figure 9 - Number of Energy Sources used per Building
(143 questionnaires - 143 responses)

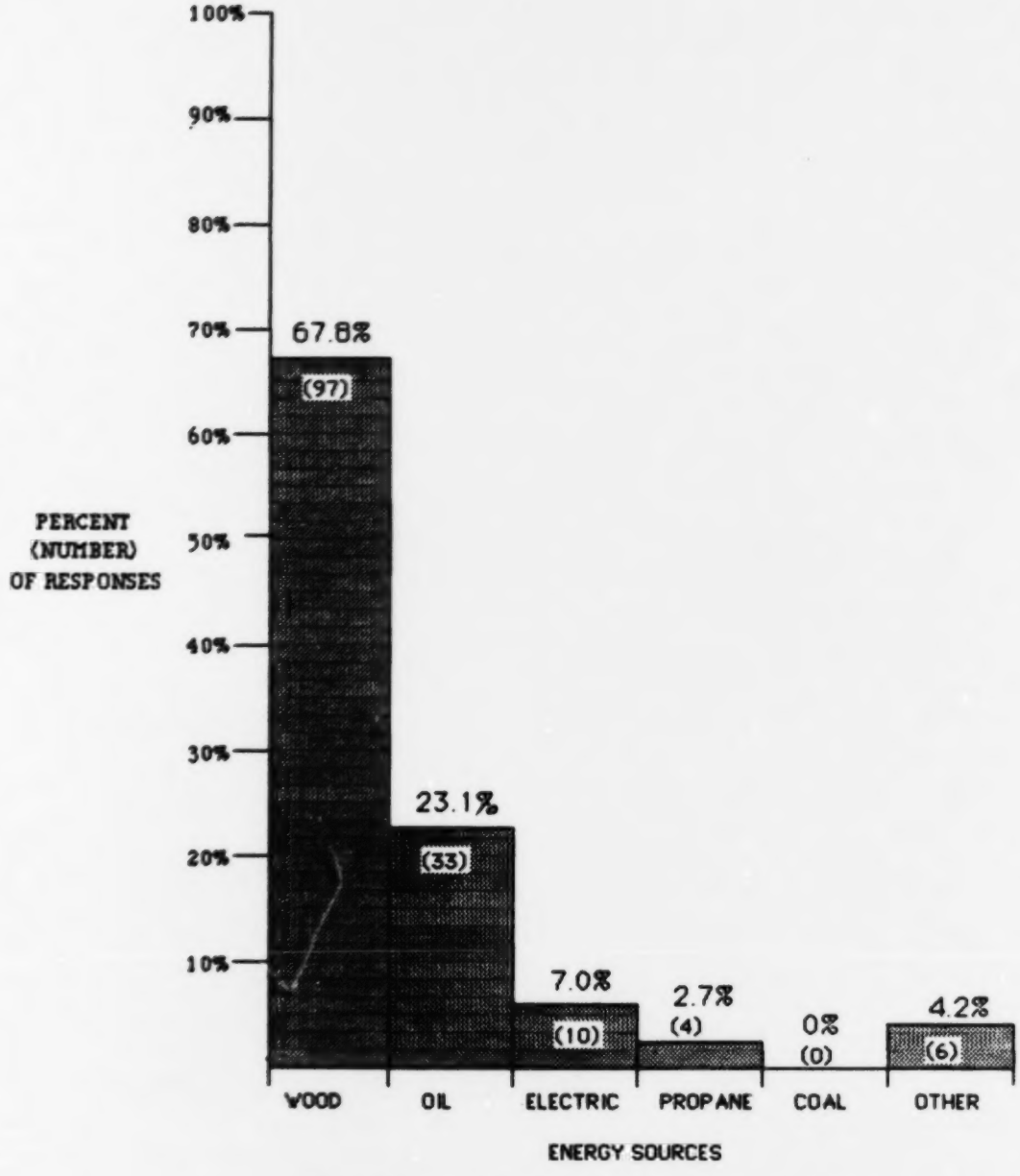


Figure 10 - Primary Energy Source Popularity *

(143 questionnaires - 150 responses)

* approximately 94% of Atlin community residents rely on more than one energy source.

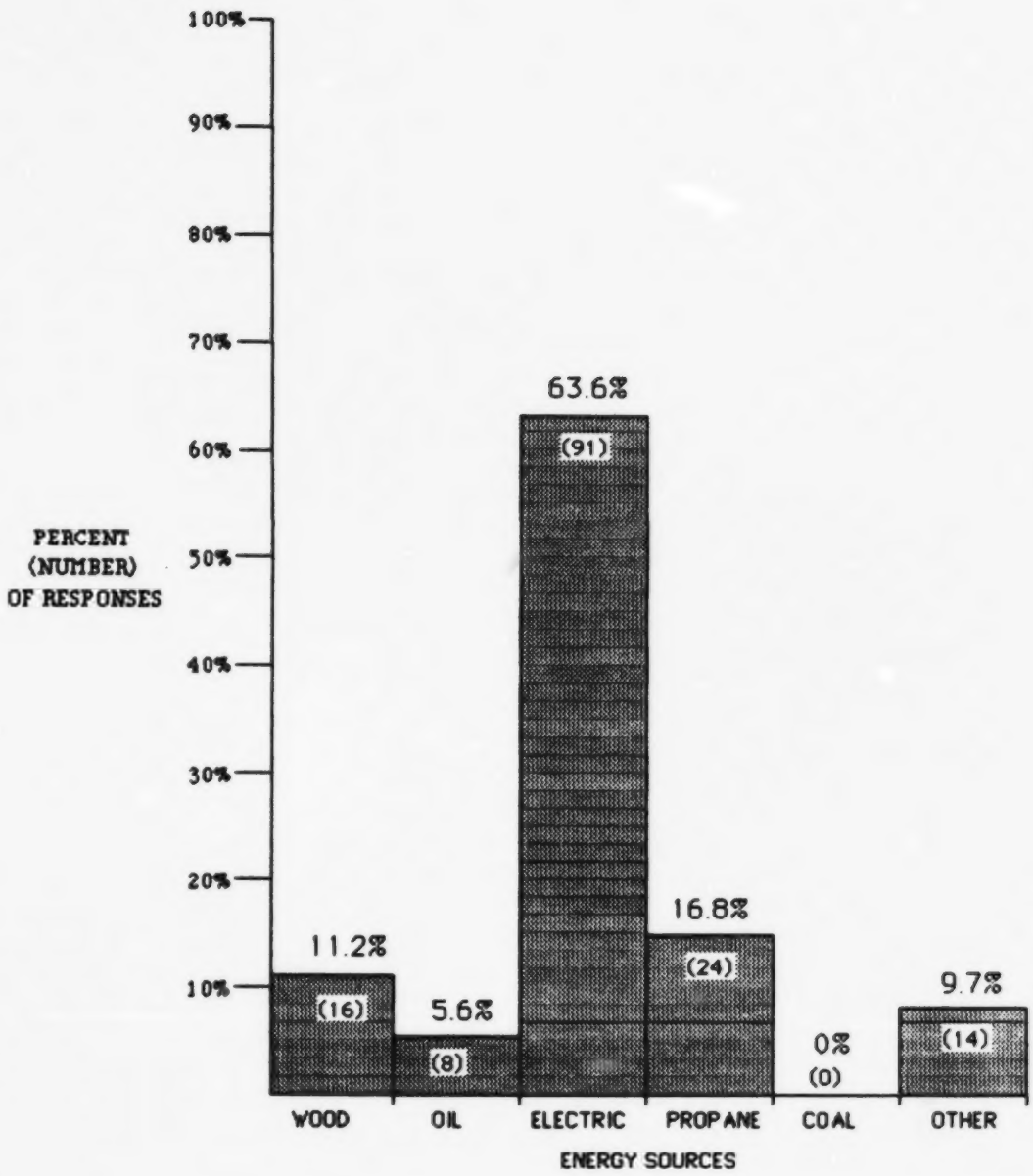


Figure 11- Secondary Energy Source Popularity *
(143 questionnaires - 158 responses)

* approximately 94% of Atlin community residence rely on more than one energy source.

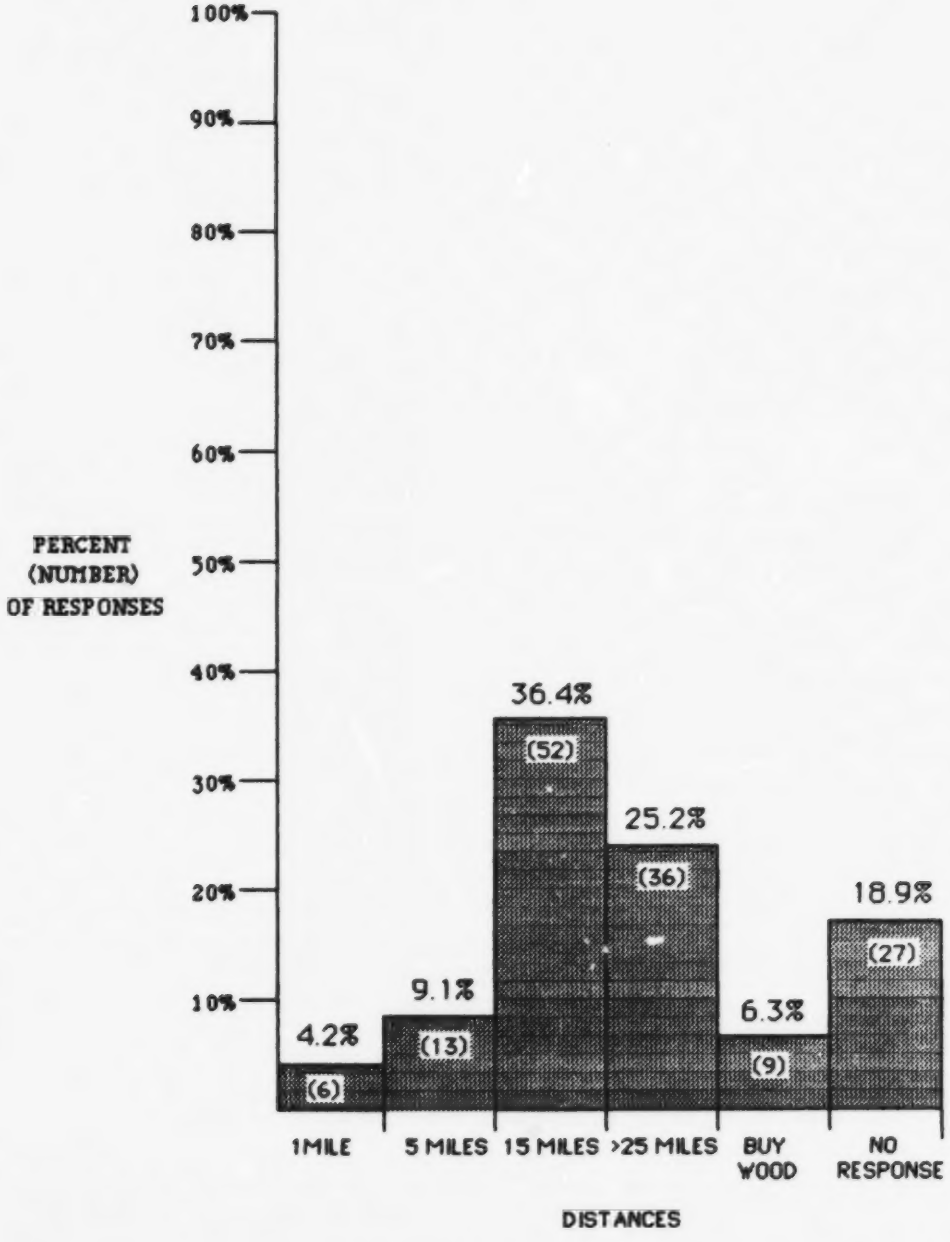


Figure 12 - Maximum Distance an Individual is Prepared to Travel for Firewood - 1984
(143 questionnaires - 143 responses)

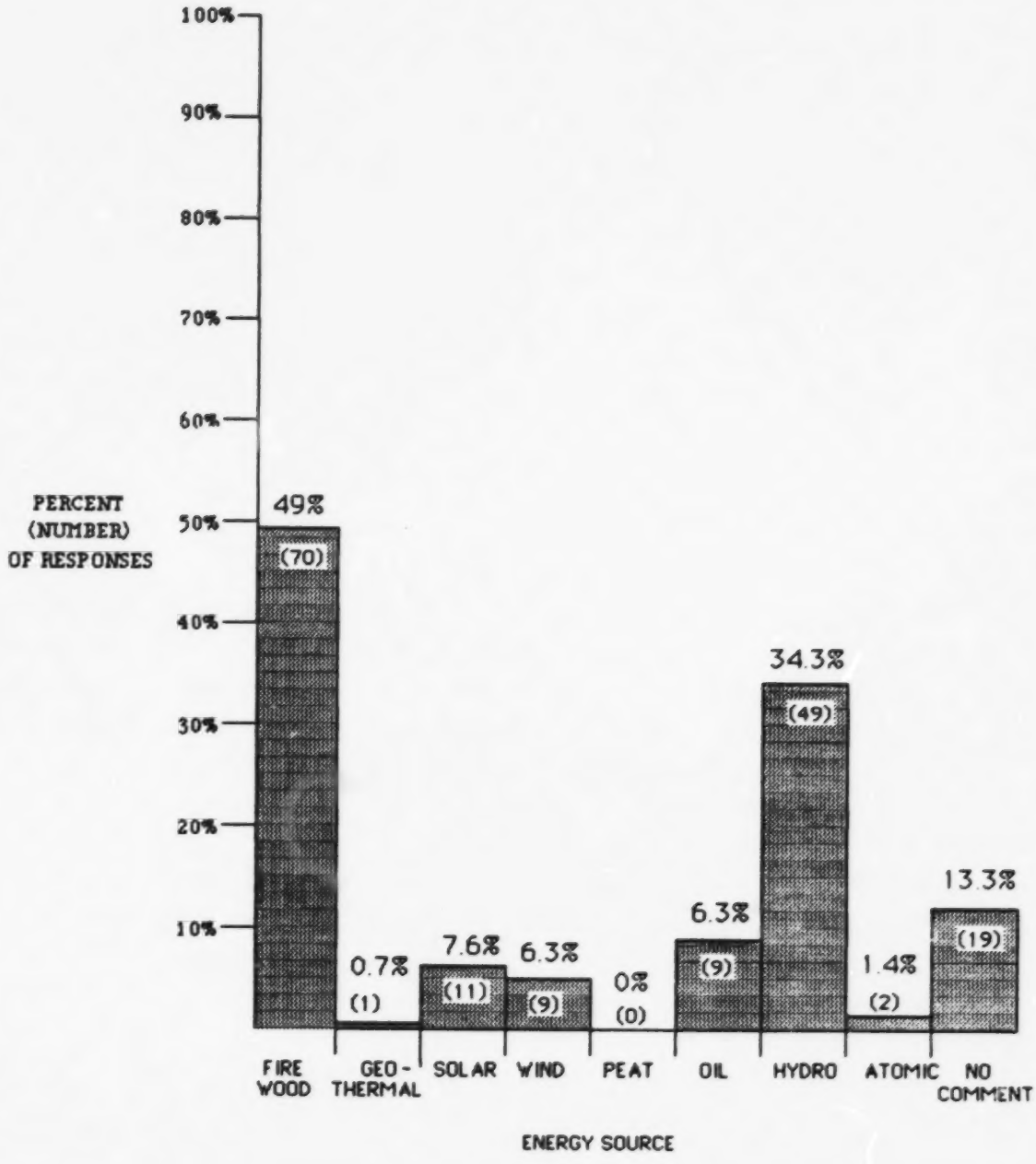


Figure 13 - Predicted Importance of Energy Sources in the Year 2001 A.D.
(143 questinnaires - 191 responses)

(9.1%) were willing to travel up to 5 miles, 52 (36.4%) would travel up to 15 miles. The remaining 36 (25.2%) residents who responded to cutting wood were prepared to travel over 25 miles, but not greater than 40 miles. Figure 12 also identifies 9 (6.3%) individuals who only bought wood and an additional 27 (18.9%) persons did not comment.

A total of 70 (49.0%) of the 143 questionnaires suggested that firewood would be the most valuable energy resource by the year 2001 (Figure 13). The 70 firewood responses was 1.5 times greater than its second closest rival being hydro with 49.

4.2.2 Heating Oil

Home heating oil was selected in the questionnaire as being the third most common energy source (Figure 8). Forty-nine (34.3%) of the 143 responses indicate this form of heating energy is used to some extent in their homes. Thirty three (23.1%) households use oil as a primary energy source; 8 (5.6%) use oil in a secondary capacity; and 2 households (1.4%) use it in a tertiary capacity.

A total of 17,561 litres of oil per month is used by the Atlin community responding to this questionnaire. Annually this figure represents 210,732 litres. At a 1984 price of $0.462 per litre accounts for $97,358; however, the majority of this oil consumption is used to heat community buildings.

Only nine (6.3%) Atlin residents believe heating oil will be the most important energy source by the year 2001.

4.2.3 Electricity

Results from the Atlin Questionnaire rated electricity first in popularity yet second in importance (Figure 8). This is because electricity is used primarily in a peripheral sense. One hundred and fifteen (80.4%) people from the 143 questioned indicated electricity was one of their energy sources. Ten of the 115 people used electricity as their primary energy source (Figure 10), 91 used it as their secondary source (Figure 11) and 14 used it as a tertiary energy source.

Atlin residents believe that in the year 2001, electricity will still the be the second most important energy source (34.3%) next to firewood (49%).

4.2.4 Propane

Propane ranked fourth in popularity as an energy source next to electricity, wood and oil. Forty six (32%) of the 143 Atlin residents questioned, indicated propane was used in the home(Figure 8). Four (2.7%) of these propane users did considered it as a primary energy source(Figure 10); 24 used propane as their secondary source (Figure 11); and the remaining 18 use propane as a tertiary source.

Monthly usage totals of 1,591 pounds resulted in annual totals of 190,092 pounds consumed. Using the 1984 cost for propane as identified in Table 2, ($0.44/pound) Atlin annually spends $83,640.

Although substantial quantities of propane are used presently, the Atlin community questionnaire indicated that this fuel was not considered to be significant by the year 2001 (Figure 13).

4.2.5 Diesel Fuel

Diesel fuel was not identified as a heat energy source in residential, commercial, community or industrial buildings. Of the 2,645,916 litres of diesel fuel used annually within the community of Atlin, 803,400 litres is used to run the generators which supply the community with electricity. The remainder is primarily used in the diesel vehicles or machinery of those individuals responding to the questionnaire.

The cost of a litre of diesel in Atlin is presently $0.463 (Table 2). This represents an estimated expenditure of $1,225,059 annually.

4.2.6 Regular Gasoline

Similar to diesel, gasoline is not used in the home, but rather for transportation and machinery purposes. Including both private and commercial establishments a total of 45,037 litres per month or 540,044 litres annually is used by the community.

Gasoline can be purchased at a cost of $0.611 per litre. Currently a total of $330,211 is spent annually for the purchase of this fuel.

4.2.7 Coal Oil (Kerosene)

This energy source is used by only 5 (3.5%) (Figure 8) people surveyed. Monthly usage is generally associated with individuals who do not use electricity. A monthly consumption rate of 13.3 litres or 159 litres annually is consumed. Estimated annual expenditure for this fuel represents less that $145.00 at the 1984 price of $0.909 per litre.

4.2.8 Other

Sources included in this category are naptha, coal and peat. Naptha is used in small incidental quantities whereas no interest is expressed in peat or coal.

5.0 ENERGY USE BY SECTOR

Total energy consumption for Atlin residents from questionnaire results is listed on Table 4. Results are categorized by sector (residential, commercial, community and industrial), and by energy source (firewood, heating oil, electricity, propane, diesel, gasoline, coal oil and others).

Energy sources and their estimated rate of demand for transportation and electric power generation within Atlin are listed in Table 2. As indicated, all the gasoline and diesel used in Atlin is used for these two purposes.

5.1 RESIDENTIAL

The residential sector is the only sector to use all forms of energy available to the Atlin area (Table 3). Ninety percent of firewood, 26.6% of heating oil, 44.4% of electricity, 59.3% of propane, less that 1% of diesel, 39% of the gasoline and all coal oil and naptha are consumed by this sector. These percentages are expected to be high realizing 122 (85%) of the questionnaire responses are from the residential sector.

5.2 COMMERCIAL

The commercial sector responding to the questionnaires represents approximately 21 (14.7%) of the total 143 responses gathered. Energy consumption for this sector is 9.8% of the cord wood, 22.3% of the heating oil, 46.6% of the electricity, 25.6% of the propane, 61.3% of the diesel and 40.8% of Atlin's total regular gasoline energy consumption (Table 3).

TABLE 3

ENERGY CONSUMPTION BY SECTOR PER MONTH

	FIREWOOD cords/mo.	HEATING OIL litres/mo.	ELECTRICITY* kW.h/mo.	PROPANE pounds/mo.	DIESEL litres/mo.	GASOLINE litres/mo.	COAL OIL litres/mo.	OTHERS (i.e. Naptha)
RESIDENTIAL REQUIREMENTS	51.96 (89.5%)	4,678 (26.6%)	37,012 (44.4%)	943 (53.3%)	1,588 (0.7%)	17,663 (39.2%)	13.25 (100%)	6 (100%)
COMMERCIAL REQUIREMENTS	5.67 (9.8%)	3,924 (22.3%)	39,696 (46.6%)	408 (25.6%)	135,180 (61.3%)	18,379 (40.8%)	Ø	Ø
COMMUNITY REQUIREMENTS	0.17 (0.3%)	7,150 (40.7%)	5,400 (6.5%)	15 (7.2%)	Ø	425 (0.9%)	Ø	Ø
INDUSTRIAL REQUIREMENTS	0.25 (0.4%)	1,809 (10.3%)	1,200 (1.4%)	225 (14.1%)	83,725 (37.9%)	8,570 (19.2%)	Ø	Ø
TOTAL	58.05	17,561	83,308	1,591	220,493	45,037	13.25	6

* B.C. Hydro Operation Division records indicate an actual consumption rate for 1982-83 of 170,166 kW.h. This difference is likely due to the time the survey was taken and that not all of B.C. Hydro's customers are located in the study area.

-45-

5.3 COMMUNITY

The community sector responding to the questionnaire represents only 7 (4.9%) of the total surveyed. As expected energy requirements are much less than the other sectors of Atlin. The portion of Atlin's total energy consumption for the community buildings is as follows: 0.3% of the wood, 40.7% of the heating oil, 6.5% of the electricity, and 7.2% of the propane, and 0.9% of the regular gasoline. Other energy sources were not used by the community sector.

5.4 INDUSTRIAL

The industrial sector represented 4 (2.8%) of the questionnaire responses. Although numbers of responses are few in this category, some energy sources have high consumption rates (Table 3). Firewood use represents only 0.4% while heating oil represents 10.3%; electricity 1.4%; propane 14.1%; diesel 37.9%; and gasoline 19.2%.

5.5 TRANSPORTATION

Results from the questionnaire (Table 4) include fuel quantities consumed by each of the four sectors. They indicate a total of 143,993 litres per month of diesel and 45,037 litres per month of gasoline are consumed by all sectors of Atlin for transportation. These quantities account for 65% of Atlin's total diesel consumption and all of Atlin's gasoline consumption.

5.6 ELECTRIC POWER GENERATION

The diesel fired generators are the largest single consumer of diesel fuel in Atlin. Recent information from B.C. Hydro indicates a consumption level of approximately 67,880 litres per month for 1983/84. The actual fuel cost for that period was $333,694.00 or approximately 41¢ per litre.

TABLE 4

AVERAGE ENERGY CONSUMPTION FOR TRANSPORTATION AND ELECTRIC POWER GENERATION PER MONTH

	FIREWOOD cords/mo.	HEATING OIL litres/mo.	ELECTRICITY kW.h/mo.	PROPANE pounds/mo.	DIESEL litres/mo.	GASOLINE litres/mo.	COAL OIL litres/mo.	OTHER (i.e. Naptha)
TRANSPORTATION	ø	ø	ø	ø	143,993	45,037	ø	ø
ELECTRIC POWER GENERATION	ø	ø	ø	ø	67,880*	ø	ø	ø

* The revised estimate based on the 1983/84 level of consumption is 67,880 litres per month as opposed to the earlier estimate of 76,500 litres per month.

6.0 VIABLE ENERGY ALTERNATIVES

6.1 INTRODUCTION

The Federal Department of Energy, Mines and Resources has supplied funding to review energy alternatives directed at off-oil programs. Reviewing the present energy situation in Atlin (1984 questionnaire and community presentations and meeting with Reid Crowther & Partners Limited), a small scale hydro project and a waste heat recovery system from the diesel electric generating plants, appear to be the only feasible projects financially or at the wish of the community.

In the following section (6.2), the logistics of small scale hydro are reviewed in detail. Atlin residents are aware of the increase in unit costs of electricity produced by a hydro project, but because of the increased electrical self sufficiency for the future, consider it a viable long term possibility. Some of the proposed sites could supply firm power year round, others need support from diesel electric generation.

The second alternative energy system reviewed in detail, is waste heat recovery systems (Section 6.3) from the B.C. Hydro diesel fired electric generators presently being used in Atlin. This alternate energy source would somewhat lessen the subsidy costs absorbed by B.C. Hydro to produce electricity in this northern community, but does not allow the community much less dependence from refined petroleum products.

6.2 ATLIN SMALL HYDRO INVESTIGATION

6.2.1 Development Criteria for Small Hydro

The economic development of small hydro is dependent upon many factors. Among the most significant of these are conditions which affect the initial cost and the rate of payback.

The initial cost is affected by the installed capacity, length and inclination of the penstock, size of the dam and spillway, and environmental considerations. Site access can become a controlling factor where extensive road and bridge building is involved.

Rate of payback is largely controlled by capital cost, interest on capital, interest during construction, inflation rates, and cost of fuel for alternative thermal generation, against which the hydro plant must financially compete.

The installed capacity under ideal conditions will be sufficient to meet the energy demand during low water periods, with sufficient reserve capacity to allow for potential load growth at least as far as the payback expiry date. This can often be met on coastal sites, but on interior ones, especially in areas of low annual precipitation such as Atlin, a compromise must often be made between firm power and capital cost.

For most interior sites, the hydrology is such that stream flow drops to quite low values during the winter months. Reliable firm power is dependent upon these low flows, and firm power on run-of-river sites will be no higher than that obtainable from the lowest recorded flow. In cases where minimum flow conditions cannot meet the winter energy peak demand, energy management or a diesel peaking unit may be used to make up the shortfall. If storage of water is possible by means of a dam, either at the intake or on the upstream watershed, energy generation during winter months can be substantially improved, depending upon the economics of the storage system.

The overall cost of any hydro plant is inversely proportional to head, whilst energy output is directly proportional to head. There is an incentive therefore to maximize the available head, but a compromise must be made between head and the length of penstock. Where the inclination of the penstock averages less than 5 percent, the hydro plant may not be competitive with an equivalent diesel generator owing to the high cost of a lengthy penstock and the interest charges which accrue to it.

Environmental necessities can materially influence the location and size of the hydro plant. Minimum water release into the creek for the support of anadranomous fish can place a limit on the power, whilst the provision of a fish ladder can dramatically increase the initial cost at small sites.

Active placer mining causes a heavy bed load of sand and silt to be transported downstream, and should this be picked up by the power plant intake, severe erosion will be caused to the turbine runners. Although stilling basins can reduce sand and silt such as to limit wear to acceptable rates, placer mining upstream of the plant should be controlled.

On creeks characterized by a heavy spring run-off, ample spillway capacity must be provided which affects the initial cost in proportion to size.

In cases where storage is necessary to meet the winter energy demand, or appears as an attractive second stage enhancement, a dam or weir can be provided. Lake storage is especially valuable. On small sites it is often possible to draw the lake down below its natural level during the winter months, allowing it to naturally recharge during the spring run-off. The best arrangement for small sites such as the one at Atlin usually involves aplying a modest surcharge to the lake level during spring run-off. Sufficient water can be made available from this surcharge to meet the winter energy demand during yearly low water periods. Drawing the lake down below its natural level would be an emergency procedure reserved for occasional extremely dry years.

Investigation of fish usage of Pine Creek should be undertaken in order to design for minimum impact.

The dams required by the indicated scale of hydroelectric development are quite low, in the order of 5 m at the hydro plant intake, and 1 meter at the lake. It would be relatively inexpensive to provide fish ways at these structures.

Frazil Ice

In common with most northern streams, Pine Creek is known to experience frazil ice during the Autumn. Frazil ice is surface ice in a needlelike form and is caused by rapidly flowing water. It is possible in many instances of light frazil icing, to mitigate its effects sufficiently to enable continuous operation of the hydro plant throughout the frazil ice period. It is anticipated that frazil ice may be heavy on Pine Creek, and this expectation tends to be supported by reports from local residents. Under such conditions, the hydro plant must be shutdown to avoid damage to the turbine and to avoid filling the penstock with slush.

It will be necessary to determine the usual severity, duration, and time of appearance of frazil ice on Pine Creek. Duration is usually quite short, a matter of hours or a few days, whilst the likelihood of formation can be gauged by air temperature. On this account, we have tentatively allowed for a yearly shutdown of up to 300 hours. This appears in Section 6.2.11, which evaluates diesel fuel savings attributable to operations of the hydro plant. Shutdown periods would be covered by diesel standby.

6.2.2 Hydroelectric Prospects on Pine Creek

The present study indicates that prospects for a small hydro development on Pine Creek are good, given the high cost of diesel generation at Atlin. A number of potential sites have been identified, and these are briefly described below. Of these, Site 2 and Site 3, appear to be quite promising and a conceptual scheme with cost estimate has been provided for each in Section 6.2.8 and 6.2.10.

Site 1

This scheme would utilize all of the available head between a point on Pine Creek just upstream from the bridge 2 km east of the airstrip, and Atlin Lake. The useful head would be 118 m (387 ft). Energy potential as a run of river site would be 540 kW during the recorded extreme low period, rising to about 2680 kW for at least 48% of the average year. The provision of storage on Surprise lake could even out the capacity to about 2000 kW minimum throughout the year. This development would necessitate a 5.3 km penstock having an overall inclination of less than 3 degrees. The cost of construction of such a penstock, or waterway, would prohibit the viability of this site. On this account, it could not at present compete with diesel power, but could become economically viable in the future, as the costs associated with diesel generated electricity increase.

Site 2

This scheme utilizes a 36 m (120 ft) drop in elevation between the bridge and a point 900 m (2970 ft) downstream (Figure 14, Table 5). It is the least expensive development. The energy potential, run-of-river basis, would be 160 kW at extreme low flows rising to about 540 kW for 50-60% of the year. As a run-of-river site, this scheme could not meet the winter energy demand, and would require extensive load management and diesel peak topping during the winter evening peak loads. Lake storage would enable peak demand to be met throughout the year, up to 800 kW. A conceptual scheme and estimate is provided for Site 2.

TABLE 5

SUMMARY OF DESIGN PARAMETERS, SITES 2, 3 AND 4

Site 2 and 4	
Net head	36 m (120 ft)
Design rating	750 kW
Diameter of penstock	120cm steel pipe
Length of penstock *	900 m (2790 ft)
Quantity of water at full load	2.73 m^3/s (96.5 cfs)
Height of dam at crest level	5 m (16.5 ft)
Capacity of spillway	50 m^3/s (1765 cfs)
Maximum available flow	3 m^3/s (106 cfs)
Maximum potential	823 kW
Site 3	
Net head	68 m (225 ft)
Design rating	750 kW
Diameter of penstock	120cm steel pipe
Length of penstock	1800 m (5940 ft)
Quantity of water at full load	1.45 m^3/s (51.5 cfs)
Height of dam at crest level	5 m (16.5 ft)
Capacity of spillway	50 m^3/s (1765 cfs)
Maximum available flow	3 m^3/s (106 cfs)
Maximum potential	1544 kW

Turbine efficiency, full load = .84

Generator efficiency = .93

* Site 4 penstock approx. 606 m (2000 ft)

Site 3

This scheme is similar to site 2, but makes use of a 68 m (225 ft) drop in elevation from the bridge to a point about 1800 m (5940 ft) downstream (Figure 14, Table 5). The energy potential on a run-of-river basis would be about 308 kW at extreme low flows rising to 1544 kW for 50-60% of the year. Load management and diesel peak topping would be required during the winter peak times, but to a lesser extent than with Site 2. Minimal lake storage would provide, however, year-round firm power with sufficient water for additional capacity to 1544 kW. A conceptual scheme and cost estimate is provided for Site 3.

Site 4

This is a proposed redevelopment of the original Noland Mine power plant (refer to Figure 15). Details of this plant are given in Section 6.2.4. The canal would be renovated and lined with concrete or asphalt paving. The water capacity would be $3m^3/s$ (106 cfs) which could provide 832 kW.

In order to avoid freezing problems, the water velocity must be maintained near canal capacity at all times during severe freezing weather. For this reason, the canal must be lined and a regulating structure provided at the lake. A detailed estimate for this site cannot be made until the canal is surveyed and studied, but a rough estimate is included in Section 6.2.10. If extensive placer mining on Pine Creek is envisaged, this site may be a practical alternative.

6.2.3 Environmental Considerations

This project could potentially influence local fisheries in three ways. First, construction of dams at the hydro plant intake and at Surprise Lake would prevent migration between Atlin and Surprise Lakes. Second, the low dam needed at Surprise Lake may produce minor alterations in shoreline conditions which may influence lake fisheries. Also, during winter low flows all the flow in Pine Creek may be diverted to the hydro plant, effectively drying up about seven kilometers of the river. This would impact on any fish overwintering in this creek.

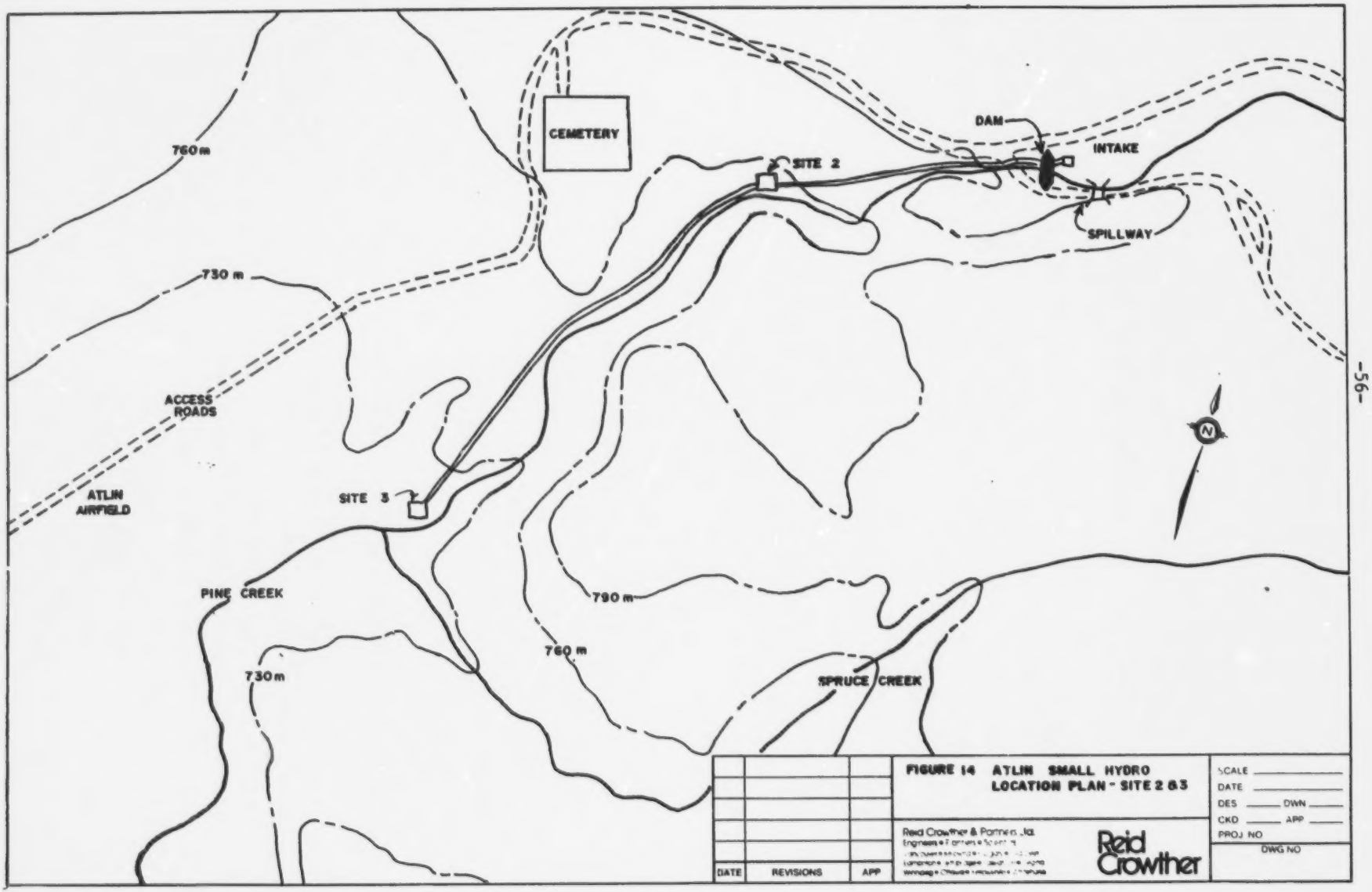


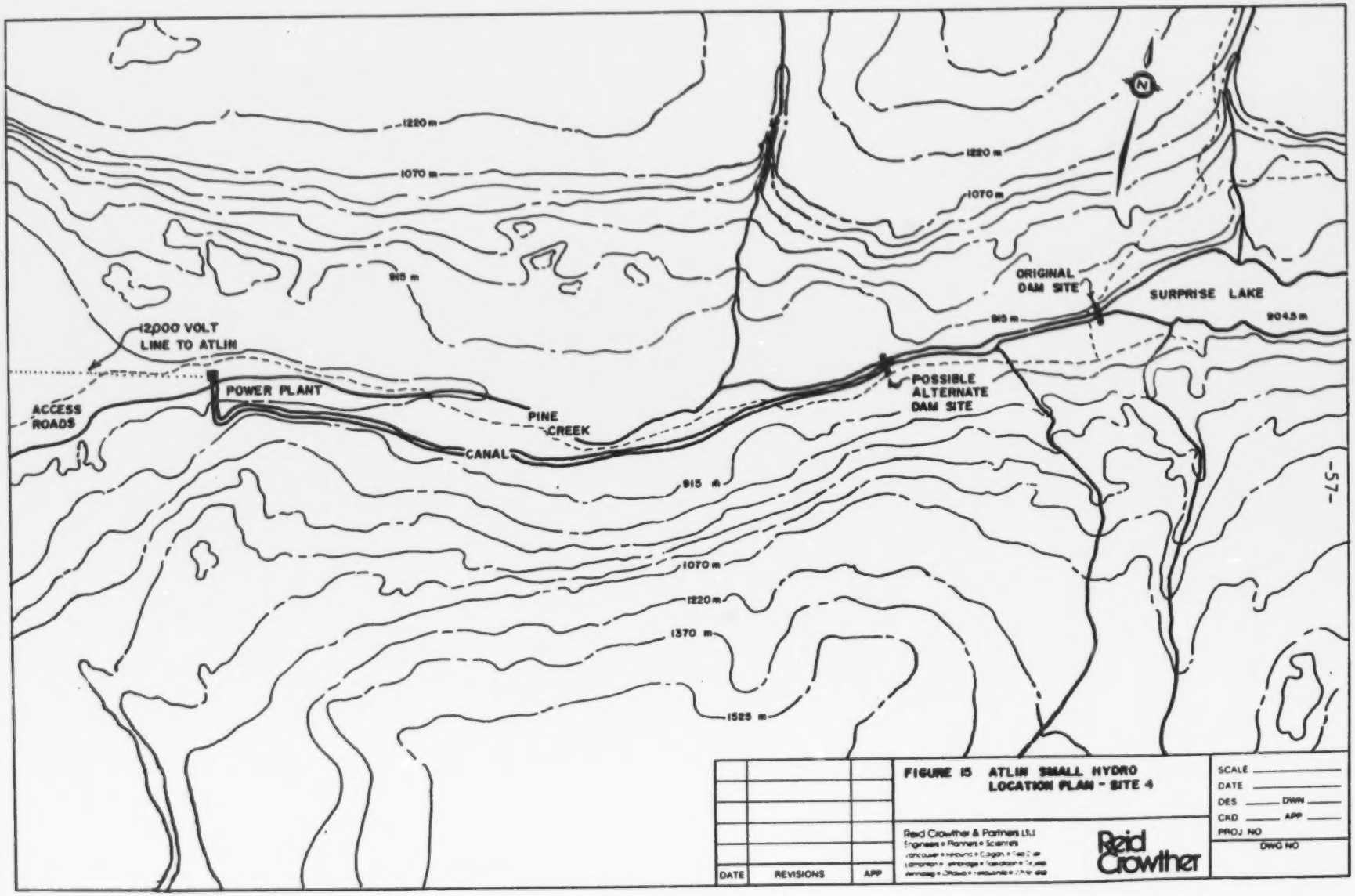
FIGURE 14 ATLIN SMALL HYDRO
LOCATION PLAN - SITE 2 & 3

DATE	REVISIONS	APP

Reid Crowther & Partners Ltd.
Engineers • Planners • Scientists

Reid Crowther

SCALE
DATE
DES DWN
CKD APP
PROJ NO
DWG NO


1220 m
1070 m
915 m
1220 m
1070 m
ORIGINAL DAM SITE
SURPRISE LAKE
904.5 m
915 m
12,000 VOLT LINE TO ATLIN
POWER PLANT
ACCESS ROADS
PINE CREEK
CANAL
POSSIBLE ALTERNATE DAM SITE
915 m
1070 m
1220 m
1370 m
1525 m
N
DATE
REVISIONS
APP
FIGURE 15 ATLIN SMALL HYDRO
LOCATION PLAN - SITE 4
SCALE
DATE
DES
DWN
CKD
APP
PROJ NO
DWG NO
Reid Crowther & Partners Ltd.
Engineers • Planners • Scientists
Reid Crowther

6.2.4 Review of Accessible Data

Research of available information has revealed a number of commentaries on hydro power for Atlin.

In 1956, a study(1) was undertaken for the B.C. Power Commission covering aspects of village electrification. The Noland mine power plant was considered a possibility, but was discounted because of the poor condition of both the machinery and the canal, which limited the power output to 400 kW. Rating of the plant when new was 600 kW 4600 V 3 phase 60 Hz. The canal was described as semi-circular in cross-section, 15 ft. wide by 7 ft. deep. It was 4-1/2 miles long. The power plant was connected to it by means of a 30" dia. steel penstock 2000 ft. long.

The Noland mine hydro plant was closed down in 1957 and the machinery was left unattended. No details as to the construction data were found. During the operating life, difficulties were experienced with icing in the canal, and it appears that mining was curtailed during the severe winter months. It is not known whether icing in the canal was the sole cause. In modern design practice, icing can be controlled by maintaining suitable water velocities which often require completely lined canals.

In 1977, B.C. Hydro produced a short commentary on small hydro potential at Atlin. No detailed hydrology or conceptual plans were developed. One scheme was for 15000 kW on Atlin Lake, beyond the scale of present needs; the Pine Creek scheme was for 1000 kW.

The large scheme did necessitate the construction of a high dam so that consecutive yearly run-offs can be stored.

(1) W.H. Adrian, Electrification of the Village of Atlin, B.C Power Commission, Victoria, B.C.

In 1980, a large scale conceptual study was completed for the Pine Creek watershed. This scheme proposed the construction of a 30 meter high dam at the west end of Surprise Lake, with a power canal leading to a point overlooking Atlin Lake south of the Village. The order of magnitude was 6000 kW. Again, the scale of this scheme is beyond the scope of present needs.

The above studies, although interesting, are not very useful to the present study. For this reason, RCPL has conducted an independent hydrological study, the results of which appear in Section 6.2.6.

Information was obtained from B.C. Hydro on yearly energy demand for Atlin together with the approximate daily load curve. These data appear in Section 6.2.5 following.

6.2.5 B.C. Hydro Data Review and Forecast

According to information received from B.C. Hydro Operating Division, the 1983/1984 peak load at Atlin was 530 kW, and generation was 2.49 GW.h. The energy demand is considerably less during summer months. The daily and yearly energy demands are graphically represented in Figures 16 and 17.

The energy demand has been projected forward, from 1983-84 to 1999-2000, at 2% and 4% annual load growths. (See Tables 7 and 8, Section 6.2.12). These tables show that at 2% annual growth, the peak demand will be 750 kw by year 1996-1997. At 4% annual growth, the peak load demands will reach 750 Kw by year 1991, and 1097 Kw by year 1999-2000.

The daily demand curve indicates the potential for peak topping using load management techniques.

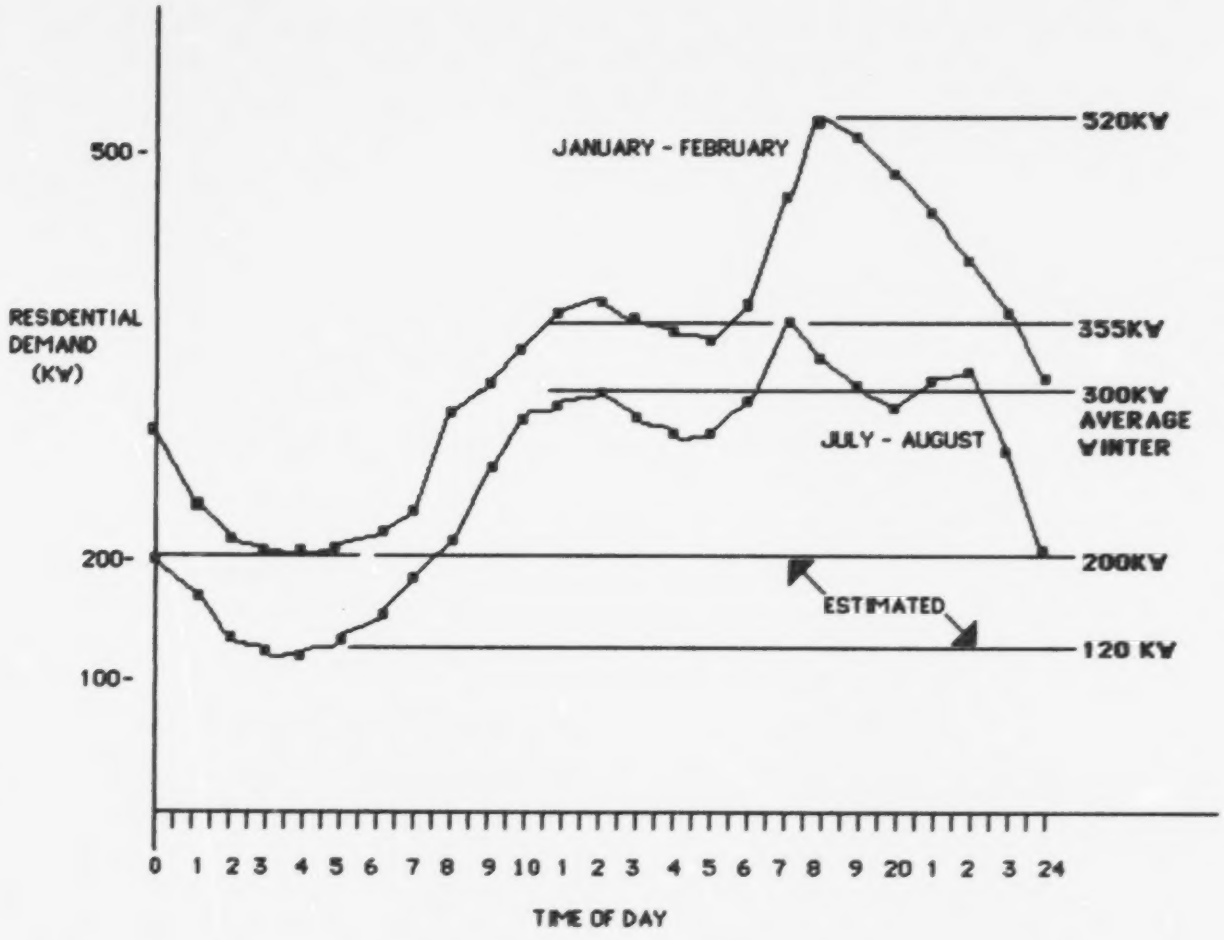


Figure 16 : Approximate Daily Load Curve, Atlin Small Hydro.

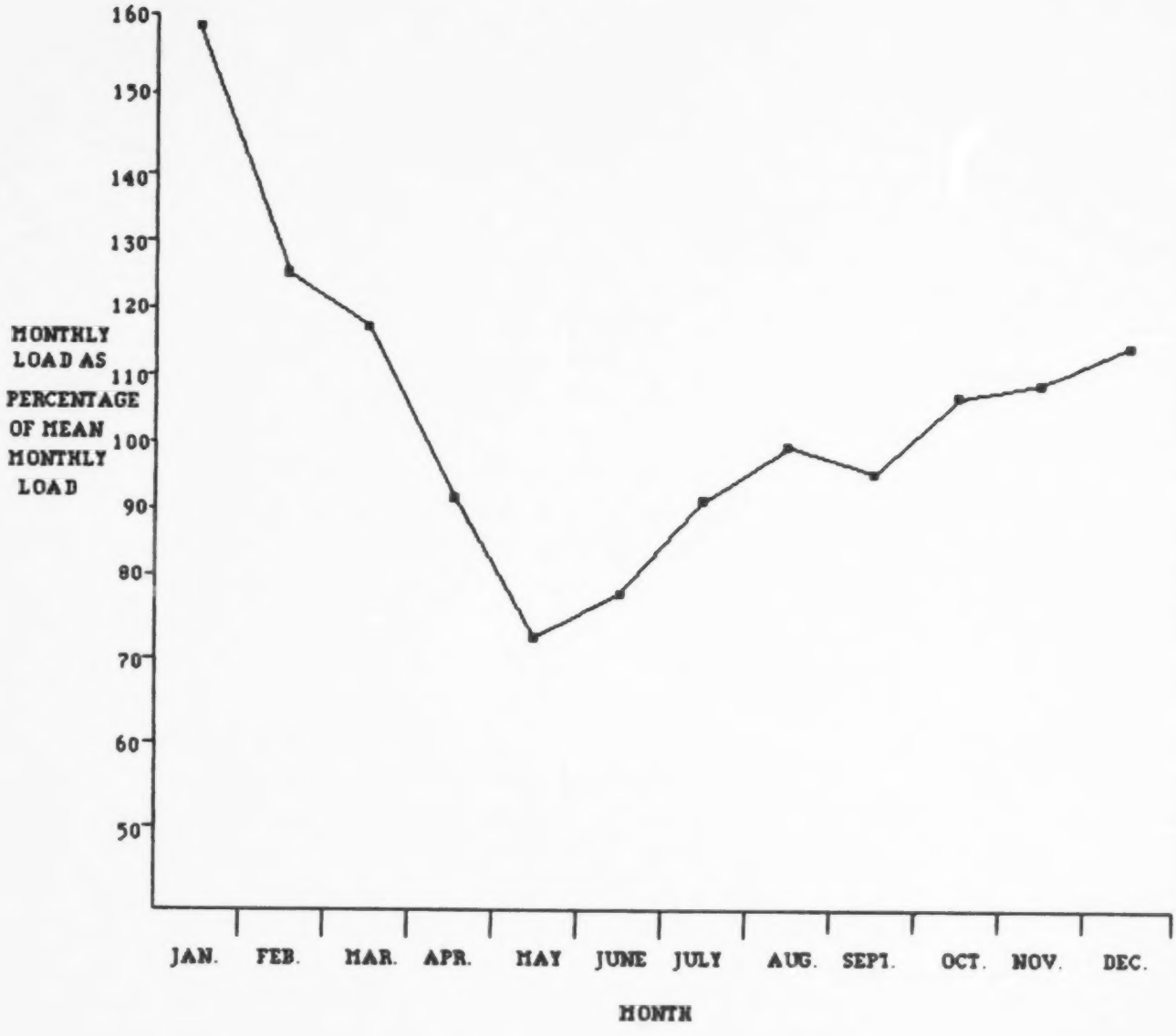


Figure 17 - Electrical Load Patterns in Atlin, 1983.

6.2.6 Pine Creek Hydrology

This section describes aspects of the hydrology of Pine Creek at the proposed project hydro plant intake site some 7 kilometers upstream of the mouth of the stream. The local climatological and surface flow records are discussed. Estimates of flood flows, seven day low flows and the duration curve of daily discharges are included.

6.2.6.1 Climatologic Records

Daily precipitation and temperature records were collected at the Atlin townsite from 1941 - 1946 and 1966 to present. The missing years cover much of the period when flow records were collected on Pine Creek.

Fifteen years of snow survey records are available at the Atlin Lake site (#149; Ministry of the Environment). The snow survey course is at an elevation of 790 m and does not reflect conditions in the portion of the basin above Surprise Lake.

6.2.6.2 Hydrologic Records

Flow records are available at Pine Creek near Atlin (09AA008) gauging station. The record is based on continuous manual observations for 1955 - 1961, seasonal observations between 1962 and 1965 and continuous manual observations from 1966 to 1970.

These records were collected near the mouth of Pine Creek where the drainage area is 697 km^2. The proposed project site is several kilometers upstream, above Spruce Creek, where the drainage area is approximately 560 km^2. The Water Survey of Canada records were prorated by a factor of 0.80 to reflect this decreased contributing area.

Flows are presently described as natural, but were influenced by the operation of an old storage dam on Surprise Lake during part of the period when flow records were collected.

6.2.7 Flood Discharges

Annual maximum discharges typically occur between late May and mid June as a result of either snowmelt or rainfall with condensation melt of snow events. High flows may also occur in the early fall period (September 1968) in response to autumn rainfall.

A frequency analysis of the early summer period maximum daily discharges, for all years of record, is plotted on Figure 18. While climatic records are incomplete, it appears that the largest 5 or 6 events are rainfall with condensation melt events. The second largest event of 21.8 m^3/s occurred on May 25, 1969 following daily rainfall totals of 9.4 mm on May 24 and 5.3 mm on May 25. Many of the smaller events seem to be caused predominately by snowmelt.

Due to this mix of generating processes for the floods, the straight line representing a log-normal distribution on Figure 18 probably underestimates flood peaks at long return periods (1). The dashed lines marked on Figure 18 represent a more realistic assessment of flood conditions and suggest that 50 year return period floods at the project site are in the 40-50m^3/s range. Those at the mouth of the creek should be from 55-60 m^3/s.

6.2.7.1 Seven Day Low Flows

Annual minimum daily discharges typically occur in the March through April period though some occur as early as mid-January (see 1957 and 1968).

A frequency analysis of the available seven day low flow (lowest average flow for seven days in a water year; Environment Canada, 1974) is presented in Figure 19.

Minimum flows over a seven day period are regularly less than 0.8 m^3 and probably are less than 0.6 m^3/s at a return period of 10 - 20 years.

(1) Waylen, P. and Woo, M. 1982. Prediction of annual flood generated by mixed processes. Water Resources Research 18; 1283 - 1286.

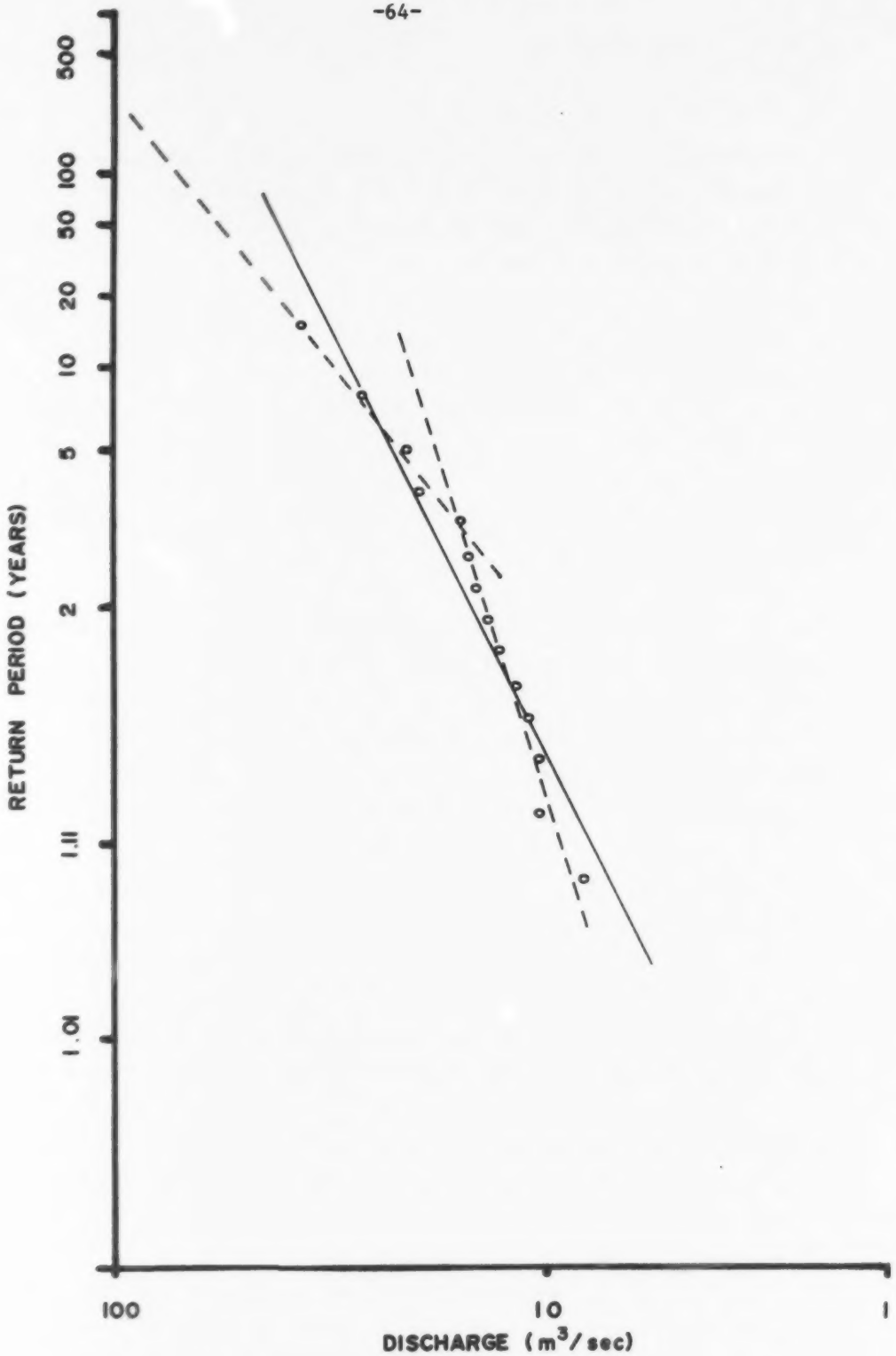


FIGURE 18 FLOOD FREQUENCY ANALYSIS: PINE CREEK AT PROJECT SITE
(REDUCED FROM 09AA0008; 1956-62, 1964-70)

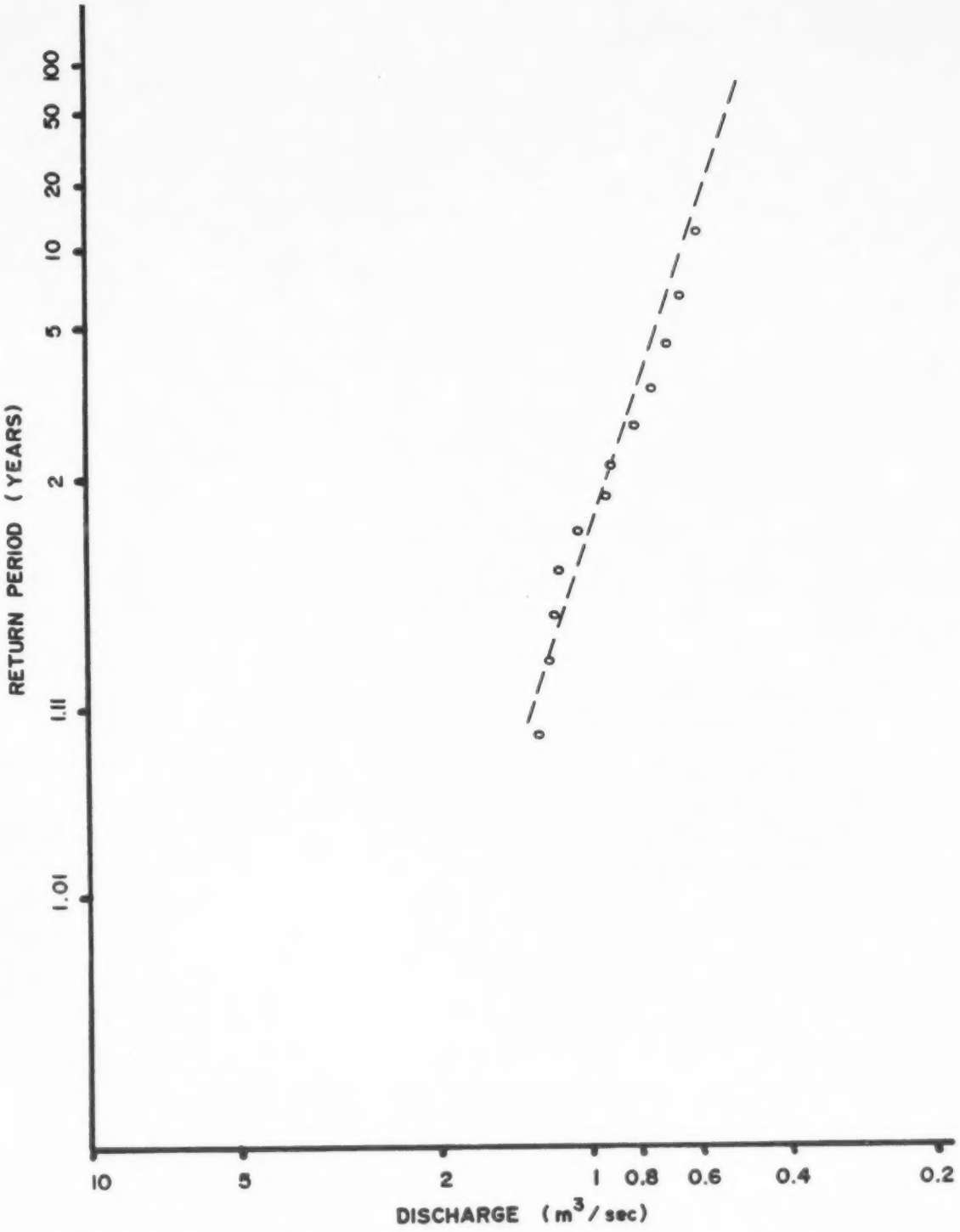


FIGURE 19 SEVEN DAY LOW FLOW ANALYSIS: PINE CREEK AT PROJECT SITE
(REDUCED FROM 09AA0008, 1956-62, 1964-70)

6.2.7.2 Flow Duration

A flow duration analysis for the project site is presented in Figure 20. These results are based on calendar years with complete flow data; 1956 - 1959 and 1966 - 1969, eight years of record.

6.2.7.3 Surprise Lake Storage

An estimate of the storage necessary to maintain certain flow levels over the winter period at the project site was completed. Analysis was based on the driest winter of record - September 1956 through April 1957.

Minimum Winter Flow Level (m^3/s)	Necessary Storage (m^3)	Approximate Storage Change on Surprise Lake (m)
1.4	7.3×10^6	0.23
2.5	22.3×10^6	0.7
3.0	29.9×10^6	0.9

Changes in levels of Surprise Lake are calculated from an estimated lake surface area of 32 km^2.

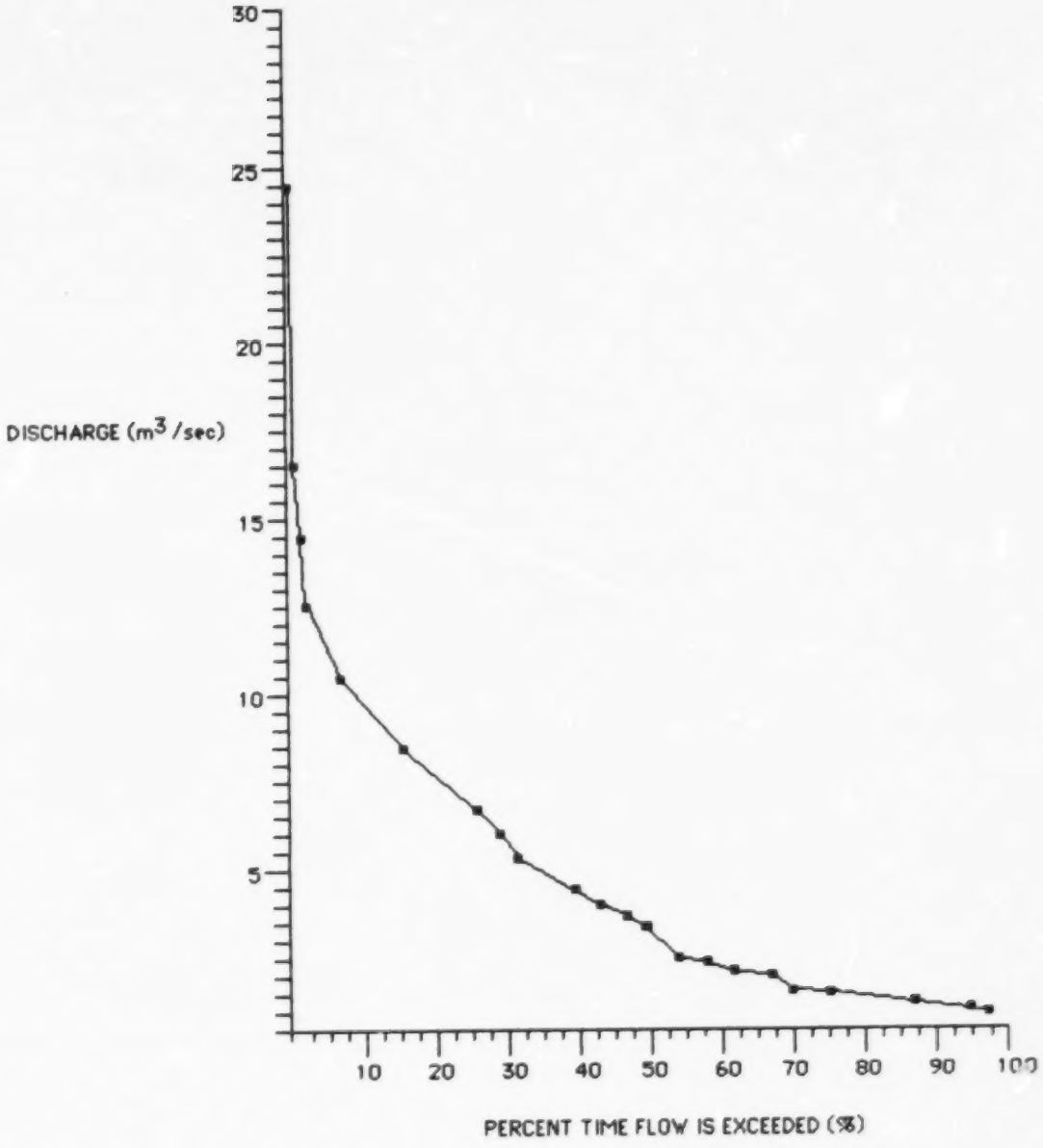


Figure 20 : Duration Curve for Daily Discharges on Pine Creek
(reduced from 09AA008; 1956 - 1959, 1966 - 1969)

6.2.8 Conceptual Design

This section details the design parameters and performance of the hydro developments considered for Atlin.

Section 6.2.5 of this report describes the necessary scale, whilst Section 6.2.6 describes the site hydrology.

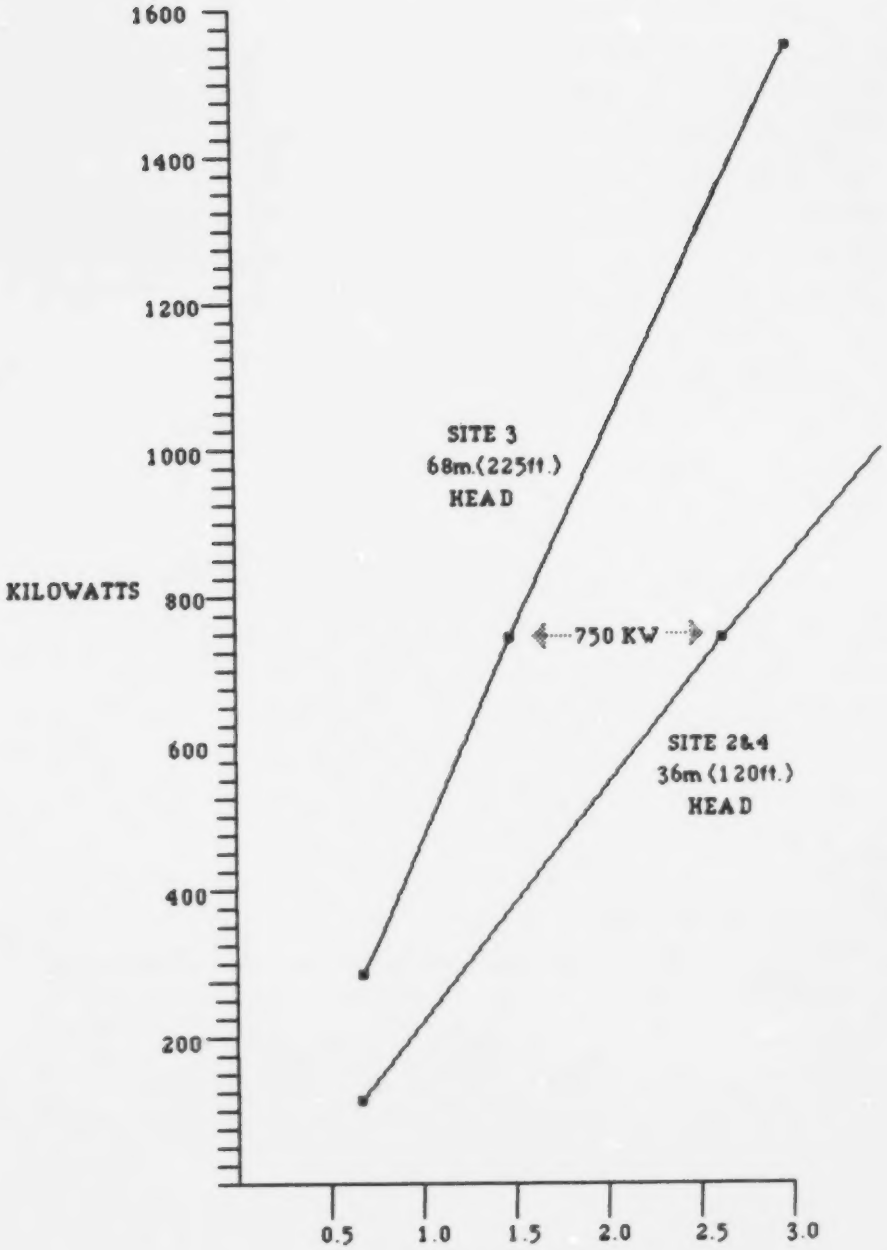
The minimum installed capacity at either of Site 2, 3 or 4 is 750 kW whilst the stream flow varies from a minimum of 0.6 m^3/s to a selected upper value of 3 m^3/s.

The available net hydraulic head at full load is 36 m (120 ft) at Site 3. Site 3 could be enlarged to 1544 kW, firm, given that the maximum storage on Surprise Lake is 1 m, and with this storage the available year-round flow would be about 3 m^3/s (106 cfs). Either Site 2 or Site 4 are limited to about 832 kW, even with storage. Table 6 below indicates energy product versus stream flow and storage.

Table 6 kW Versus Flow and Storage (refer to Figure 21)

Site 3			Site 2 and Site 4	
68 m head		Water flow	36 m head	
kW	Storage m	m^3/s	kW	Storage m
306		0.6	163	
492		0.96	262	
720	0.23	1.4	384	0.23
1028	0.46	2	548	0.46
1282	0.7	2.5	684	0.7
1544	0.9	3	832	0.9

Table 6 indicates that the minimum flow required to meet the load projection requires very modest storage. For Site 3 this amounts to about 0.26 meter (0.85 ft) and for Site 2 and 4, 0.7 meter (2.3 ft).



KW Versus Streamflow
Atlin Small Hydro

Figure 21

Table 6 also illustrates that storage is required to meet the winter peak if diesel peak topping is to be avoided. Conversely, the cost of a storage dam could be deferred by utilizing diesel peak topping and load management techniques. If storage were to be provided, a figure of 1 m would likely be chosen, as this would allow for future enhancement of the power plant to the maximum output shown in Table 6.

Site 2 and 3 were selected for cost comparison (Section 6.2.10) on the basis of maximizing the available head whilst maintaining a reasonable penstock length.

This analysis provides for firm energy. Incremental energy (short term energy available during spring run-off conditions) is not considered in this analysis. Should incremental energy become sufficiently valuable, an additional generator could be installed to provide it.

6.2.9 Summary of Data

The annual demand load at Atlin, projected into a 15 year load growth of either 2% or 4% per annum, requires an installed minimum capacity of 750 kW (see Table 7 and 8).

The hydrological data base indicates that 750 kW can be sustained on all sites throughout the year with the provision of a small amount of storage, and that on Site 3 1544 kW can be maintained.

The maximum available stream flow, with sufficient storage to maintain this flow during the 10-20 year recurring dry year cycle, appears to be somewhat over 3 m^3/s. The figure of 3 m^3/s has been selected as a design criterion.

TABLE 7

Load Scenario — 2% P.A. Load Growth

	Peak Kw	Average Kw	GWH
1984-85	614	289	2.53
1985-86	625	294	2.58
1986-87	638	300	2.63
1987-88	651	306	2.68
1988-89	661	311	2.73
1989-90	674	317	2.78
1990-91	687	323	2.83
1991-92	697	328	2.88
1992-93	710	334	2.93
1993-94	721	339	2.97
1994-95	734	345	3.03
1995-96	748	352	3.09
1996-97	763	359	3.15
1997-98	778	366	3.21
1998-99	795	373	3.27
1999-2000	808	380	3.33

Basis: B.C. Hydro reported GWH for year 1983-84 at 2.49 GWH.

Peak load management necessary in year 1996-1997.

Planning and construction of 2nd generator would take place prior to 1996-1997.

Load factor 0.47 throughout.

TABLE 8

Load Scenario			4% P.A. Load Growth
	Peak Kw	Average Kw	GWH
1984-85	614	289	2.53
1985-86	638	299	2.61
1986-87	663	311	2.72
1987-88	689	324	2.83
1988-89	716	336	2.94
1989-90	744	349	3.05
1990-91	773	363	3.18
1991-92	804	377	3.30
1992-93	836	393	3.44
1993-94	869	408	3.57
1994-95	903	424	3.71
1995-96	939	441	3.86
1996-97	976	458	4.01
1997-98	1015	477	4.17
1998-99	1055	496	4.34
1999-2000	1097	515	4.51

Basis: B.C. Hydro reported GWH for year 1983-84 at 2.49 GWH.

Planning and construction of 2nd generator would take place prior to 1990-1991. Peak load management necessary by year 1990-1991.

Load factor 0.47 throughout.

Storage volumes (Table 6) are modest. The addition of a 1 meter surcharge on the existing lake level of 904.5 m (2985 ft) above sea level is sufficient to maintain 3 m^3/s throughout the projected 7-day minimum flows.

Projected maximum flood discharge (Section 6.2.6) indicates that a spillway capacity of 50 m^3/s (1765 cfs) is necessary.

The above storage may be modified when the quantity, duration and time of water used by the placer mines on the creek are known. Although water used returns to Pine Creek, excessive use in late summer and fall could adversely affect winter lake storage.

6.2.10 Cost Estimates

The estimates herein are at a conceptual level, and variations on these costs may be expected as the work proceeds to detailed design levels.

6.2.10.1 Cost Estimate, Site 2

This estimate is based on a capacity of 750 kW developed on a head of 36 m (120 ft). Costs include transportation and labour.

Turbine and Electrical

Turbine - Generator, 750 kW	$ 330,000	
Control panels	$ 36,000	
Transformer	$ 18,000	
Building electrical services	$ 5,000	
Battery and auxiliaries	$ 6,000	
Trash rack heater and powerline	$ 35,000	
Sub Total		$430,000

Mechanical

Power plant steelwork	$ 3,000	
Dam and intake steelwork	$ 21,000	
Draft tube	$ 4,000	
Turbine by-pass valve	$ 12,000	
Building Heating and Ventilation	$ 3,000	
Turbine stop valve 120 cm dia.	$ 8,000	
Lifting gear (4 tonne chain block)	$ 3,500	
Miscellaneous	$ 3,500	
Sub Total		$ 58,000

Civil Works

Dam, intake and spillway	$ 280,000	
Penstock 120 cm steel, 900 m @ $495/m	445,400	
Penstock excavation & backfill 1400 m^3 @ $7.00/$m^3$	9,800	
Power plant site prep. 200 m^3 @ $7.00/$m^3$	1,400	
Power plant excavation 200 m^3 @ $7.00/$m^3$	1,400	
Power plant concrete 65 m^3 @ $700.00	45,000	
Steel penstock section, 1000 mm steel, 30 m	16,000	
Thrust Block 10 m^3 at $700.00	7,000	
Access roads 1 Km, gravel	15,000	
Stream improvements 500 m^3 at $8.00	4,000	
Building superstructure 70 m^3 prefab at $100.	7,000	
Building insulation and lining	8,000	
Chain link fencing 200 m at $20.00	4,000	
Materials & Aggregates contingency sum	45,000	
Sub Total		$ 889,000

Power Line

4.5 km 25000 volt 3 phase wood pole line	$ 80,000	
Construction at B.C. Hydro	15,000	
Sub Total		$ 95,000

Manning

Mobilization	$ 50,000	
Maintenance 1800 man-days @ $60.00	108,000	
Transportation	15,000	
Sub Total		$ 173,000

Engineering

Feasibility Study		$ 60,000	
Engineering Design		180,000	
Engineering Supervision		35,000	
	Sub Total		$ 275,000

Total Project Cost, run-of-river	$1,920,000
Total Project Cost with Storage *	$2,213,000

(Interest during Construction not included)

Cost per kW run of river 750 kW	$ 2,560
Cost per kW with storage dam	$ 2,950

* Cost of 1 m storage dam $293,000 plus ancillary costs of lake clearing, environmental land settlements, etc.

6.2.10.2 Cost Estimate, Site 3

This estimate is based on a capacity of 750 kW developed on a head of 68 m (225 ft). Costs included transportation and labour.

Turbine and Electrical

Turbine & Generator, 750 kW	$ 320,000	
Control panels	$ 36,000	
Transformer	$ 18,000	
Building electrical services	$ 5,000	
Battery and auxiliaries	$ 6,000	
Trash rack heater and powerline	$ 45,000	
Sub Total		$ 430,000

Mechanical

$ 58,000

As estimate Site 2, sub total

Civil Works

Penstock 120 cm steel, 1800m @ $495/m	$ 891,000	
Penstock trenching & backfill 3000 m^3 @ $10.00 (includes additional costs for difficult terrain)	30,000	
All other items same as Site 2	434,000	
Sub Total		$1,355,000

Power Line

4 km 25000 volt 3 phase wood pole	$ 75,000	
Construction at B.C. Hydro	15,000	
Sub Total		$ 90,000

Manning

Mobilization	$ 50,000	
Maintenance 1900 man days @ $60.00	114,000	
Transportation	15,000	
Sub Total		$ 179,000

Engineering

Feasibility Study	$ 40,000	
Engineering Design	200,000	
Engineering Supervision	35,000	
Sub Total		$ 275,000

Total Project cost, run-of-river	$2,387,000
Total Project cost with storage *	$2,680,000
Cost per kW run-of-river	$ 3,180
Cost per kW with storage (dam required)	$ 3,570

* Cost of 1 m storage dam $ 293,000

Note: Cost for 1000 kW unit approx. 5% higher (about $2,780,000) for the project with storage and $2730 per kW installed.

(Interest during construction not included)

6.2.10.3 Cost Estimate, Storage Dam

Regulating dam	$ 135,000	
Regulating gear	$ 28,000	
Additional site preparation	$ 90,000	
Total		$ 293,000

Note:
This structure would be provided with a spillway and flow regulator. The regulating gear is mannually adjustable according to a prepared schedule. Remote Control would add about $100,000 to the cost.

Development costs on Site 2 and 3 are very little different at this conceptual stage. When these sites are fine tuned at the feasibility study level, larger differences may appear. On the basis of present information, Site 3 is preferable, owing to the greater scope for future development. The estimates are within the normal range of development costs for medium head sites.

Site 4 development costs depend upon a detailed study of canal rehabilitation. A rough estimate would be in the order of $4,000,000 or a cost per kW installed of $5000 for 750 kW.

Hydro development at Atlin will be strongly affected by transportation logistics and maintenance provisions for the work force. The given estimates will be sensitive to these factors.

6.2.11 Unit Energy Costs

Unit energy costs of hydro-electric operation are very load dependent. However, assuming the following:

- a connected load factor for year one of 38%.
- a 30 year payback period (reasonable for hydroelectric plants)
- 750 kW unit installed
- a standard 8760 hour year
- 2% load growth per year

and allowance for operating and maintenance costs based on:

o operator $40,000/year	$40,000
o accounting charges	$10,000
o debt retire for turbine runner at 10 years	$10,000
o servicing, maintenance	$ 5,000
o fuel for 2 weeks diesel operations (at $.15 kW.h)	$20,000
	$85,000

The unit costs including this allowance for operating and maintenance costs are:

- For Site 2

Capital cost of $2,213,000	
30 year debt retirement	$250,000
Operating & Maintenance (est.)	85,000
	$335,000

At 38% connected load factor Unit Costs are:

$$\frac{(\$335,000)}{750x.38x8760} = \$.134/kW.h$$

However, once the load factor has grown to 100% the unit costs would reduce to:

$.051/kW.h

o For Site 3

Capital cost of $2,680,000

30 year debt retirement	$ 300,000
O & M costs (estimated)	85,000
	$ 385,000

At 38% connected load factor, unit costs are:

$$\frac{385,000}{750x.38x8760} = \$.154/kW.h$$

Again, once the load factor increases to 100% the unit costs would reduce to $.06/kW.h

These costs compare quite favourably with reported diesel generation costs of only $.17 to $.20/kW.h; however, this does not include the costs of transmission, distribution, meter reading etc.

6.2.12 Displacement of Fuel Oil

Based on B.C. Hydro 1983-84 figures of 2.49 GWH and corresonding average power of 284 kW.

- Fuel consumption 83-84 - 814,641 litres
  Cost of fuel $0.4188/litre
  (includes $8,000 for lube oil) Cost $341,293

- With diesel standby for 300 hours per year:
  Fuel consumption 3-4% of annual = 27698 litres
  Cost of fuel $0.4188/litre
  Cost $ 11,599

- Fuel saving for year 83-84
  $341,293 - $11,599 = $329,694

Fuel cost savings will rise in accordance with increasing GWH and rising fuel costs. Fuel costs and projected B.C. Hydro operating losses are shown in Table 9 (following).

One important intangible cost is that of Water Rights. Before any serious discussion of implementation can take place an understanding must be reached over who controls the Water Rights on Pine Creek. It is our understanding that two applications have already been submitted to the Water Rights Commission for Pine Creek.

TABLE 9

Incremental Fuel Cost and Yearly Operating Losses

Year	GWH	Litres	Unit $/L	Fuel Cost $	Atlin G.S. Operating Loss B.C. Hydro
		2% Load Growth			
1984-85	2.53	801,000	0.4188	335,000	832,000
1985-86	2.58	817,000	0.4271	349,000	882,000
1986-87	2.63	833,000	0.4356	363,000	935,000
1987-87	2.68	850,000	0.4444	378,000	991,000
1988-89	2.73	867,000	0.4518	393,000	1,050,000
1989-90	2.78	880,000	0.4621	407,000	1,113,000
1990-91	2.83	894,000	0.4716	423,000	1,180,000
1991-92	2.88	902,000	0.4811	434,000	1,250,000
1992-93	2.93	920,000	0.4906	451,000	1,326,000
1993-94	2.97	938,000	0.5005	469,000	1,405,000
1994-95	3.03	957,000	0.5105	488,000	1,480,000
1995-96	3.09	976,000	0.5207	508,000	1,579,000
1996-97	3.15	996,000	0.5311	529,000	1,674,000
1997-98	3.21	1,016,000	0.5418	550,000	1,774,000
1998-99	3.27	1,036,000	0.5526	572,000	1,881,000
1999-2000	3.33	1,057,000	0.5636	595,000	1,994,000

Basis B.C. Hydro statistical data - Operations Division

Fuel inflation 2% P.A.

Hydro loss inflation 6% P.A.

Load growth 2% P.A.

Figures given are approximate and indicate the general ratio of fuel costs to operating loss.

6.3 WASTE HEAT RECOVERY

The production of heat is inherent in the generation of electrical energy through the use of diesel engine power as the prime mover. Although dependent on the demand characteristics of the electrical load, diesel engines produce heat during their combustion process to the extent that both external coolant systems and effective exhaust systems must be utilized to dissipate this heat. Generally, for each 100 Units of fuel energy input to a diesel electric generating system approximately:

- o 30 units is discarded through the exhaust system
- o 30 units is discharged to an engine coolant system, lost through radiant energy and noise; and
- o 40 units of energy is available as mechanical energy to the electrical equivalent.

Through the collection and utilization of the waste heat generated in the production of diesel powered electricity, the overall thermal efficiency of the generating station can be practically doubled from a non-utilization efficiency of 40% to an overall generation, collection and utilization efficiency of 80%. However, the attainable heat recovery will be somewhat dependent on the uses to which this heat can be put. For example:

- o high grade heat can be recovered from the exhaust gases to produce steam, high presure hot water or other pressurized fluid system; and
- o low grade heat can be recovered from the engine coolant system for water system preheat, domestic hot water domestic heating and other similar applications.

Of the 60 units of energy developed as waste heat, some 70% is usually available to a heat recovery systems. Simply stated, the waste heat developed is recovered through the use of heat exchanger systems designed to operate in the temperature regimes of this heat energy. Exhaust exchangers (or silencers) run with exhaust temperatures to 500^{o}C, and engine coolant systems run with coolant fluid temperatures in the 90^{o}C range.

6.3.1 Atlin Generating Station

According to information provided by B.C. Hydro, the Atlin Generating Station currently consists of:

- o 3-400 kW generating units installed within the powerhouse
- o 2-250 kW portable units external to the powerhouse

all of which are electronically governed to permit load sharing by the operating units. A summation of peak loads and monthly hourly loads is:

PRODUCTION STATISTICS - 12 MONTH SUMMARY

MONTH		PEAK	kW.h
1983	Apr	370	190,000
	May	340	179,200
	June	340	164,000
	July	300	165,600
	Aug	320	174,400
	Sept	410	188,800
	Oct	450	213,600
	Nov	480	220,000
	Dec	520	276,000
1984	Jan	530	274,800
	Feb	470	231,600
	Mar	420	216,000

6.3.2 Atlin Electrical Load

However, the demand load of the community is not the peak load. Rather, the demand load varies throughout the day and throughout the year, dependent on lifestyle, available outside light, domestic heating (both water and space), use of freezers etc. An approximate load curve for winter vs summer use, on an hourly basis is shown in Figure 16 (previously referred to in the hydro electric section). It can be seen that during the early hours of the winter, the demand load drops to approximately 200 kW, whilst during the day averages about 350 kW, and rises to an evening peak load in excess of 520 kW.

6.3.3 Available Heat

At 100% load, each 400 kW diesel generating unit rejects 508 kW to the exhaust system, and an additional 404 kW to the engine coolant system. Additionally, the diesel engine and generator develop almost 94 kW in radiant energy. Of this total heat energy, a heat recovery module could be expected to reclaim about 630 kW (2 million btu/hr) or in other terms, provide usable heat for about 1900 m^2 of building.[1]

At a fuel cost of $.55/litre for heating fuel, this represents a current fuel oil equivalent, assuming a heating requirement of one third the year (2900 hours), of $145,000.[2] However, a review of the daily demand curve shows that a more reasonable average generating level would be 300 Kw, which represents about $110,000 of fuel oil equivalent.

1 an average value of .33 kW/m^2 for building heating load has been used.

2 an average furnace efficiency of 60% has been used.

6.3.4 Recovery System

The system to recover the waste heat of the diesel generating station is neither overly expensive nor complicated. In discussions with manufacturers in Vancouver, a recovery module with all components for a 400 kW design capacity, complete with automatic valving for stand alone operation would cost in the region of $70,000. Installation costs, start-up supervision, interconnect piping and connection would add another $15,000. Therefore, a $100,000 budget (including design and contingency) would provide a heat recovery module.

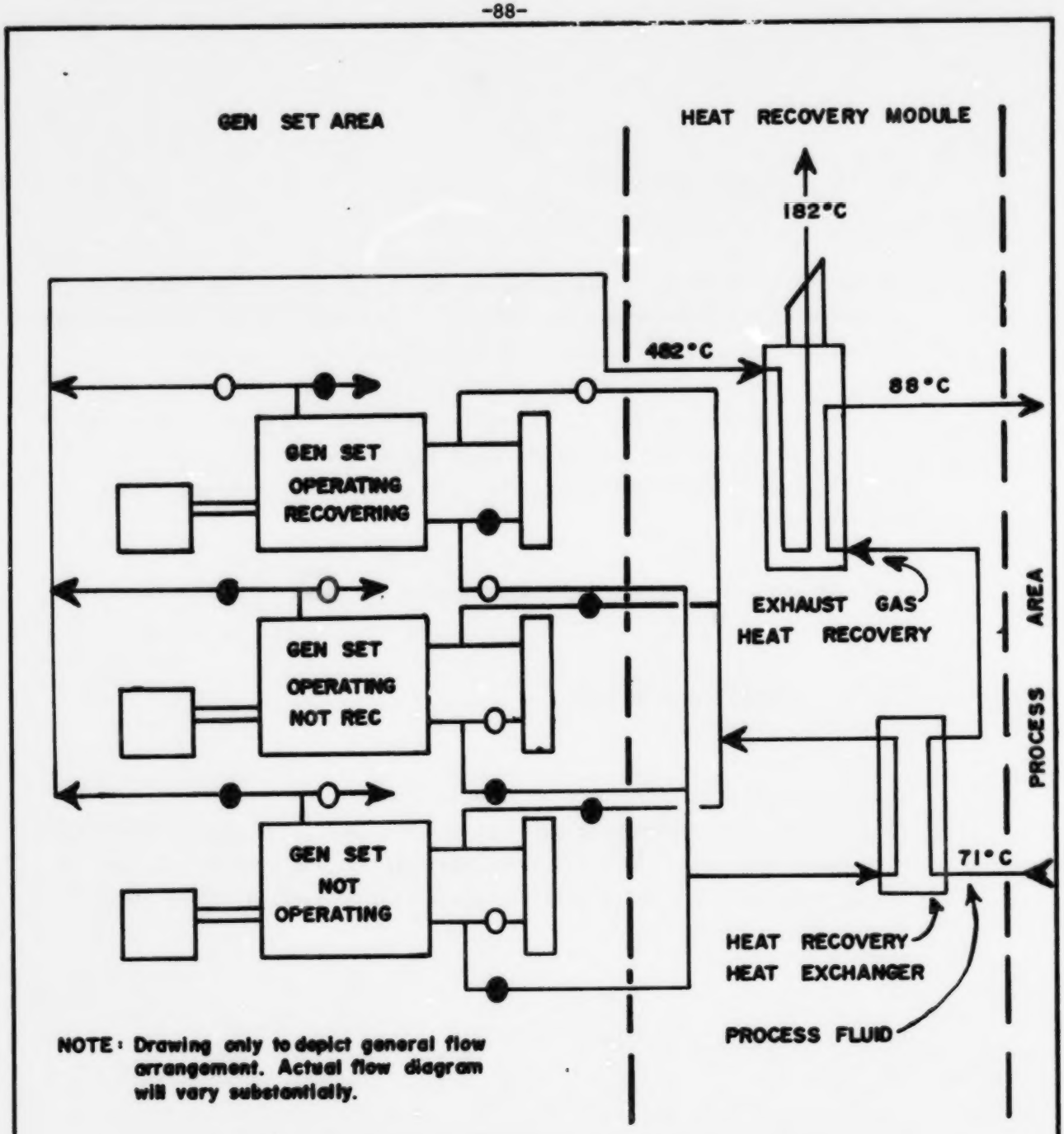
A simple one line sketch of a recovery system is shown in Figure 22.

6.3.5 Heat Transportation

Unfortunately, even with the temperature of the recovery module circulation fluid in the ideal space heating range of about 80°C, the losses associated with fluid transport, the costs associated with piping systems and the energy required for pumping will not allow load connection at any great distance from the plant.

6.3.6 Heat Distribution

From the waste heat recovery equipment, a system of buried hot water distribution lines would provide circulation of the recovered waste heat to selected load centres. A circulation rate of about 1100 litres per minute would be available, at a temperature of 80°C, to provide 630 kW.



NOTE: Drawing only to depict general flow arrangement. Actual flow diagram will vary substantially.

INPROHEAT
INDUSTRIAL PROCESS HEAT ENGINEERING LTD.

DATE	REVISIONS	APP

FIGURE 22 SIMPLIFIED HEAT RECOVERY MODULE PROCESS FLOW DIAGRAM.

Reid Crowther & Partners Ltd.
Engineers • Planners • Scientists
Vancouver • Kelowna • Calgary • Red Deer
Edmonton • Lethbridge • Saskatoon • Regina
Winnipeg • Ottawa • Yellowknife • Whitehorse

Reid Crowther

SCALE
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Distribution lines for this flow rate would consist of 10 cm diameter steel lines, plastic wrapped for protection, insulated with 5 cm foam insulation, buried together in an 2.5 metre deep trench. Although insulated plastic piping would be the most desirable material for ease of installation, the temperature of the heated fluid together with the required insulation pressure in the supply loop will not permit this usage. Estimated costs for the steel pipe, installed, is broken down as follows:

	Per Metre	Per Foot
Pipe (supply and return)	$ 158	$ 48
Trench (2.5 metres deep)	16	5
Installation	10	3
Insulation	39	12
Insulation fitting	7	2
Backfill	16	5
Compact and survey	16	5
	$ 262	$ 80

Utilization heating load connection to the distribution system would depend on the type of heating system currently used in a retrofit situation, or upon the system selected for a new building. However, in general, the following systems would apply to most situations:

- hot water coils in the duct work of existing hot air systems;
- heat exchanger and circulating pumps retrofit to existing hot water systems; and
- heat exchanger, circulating pumps and hot water baseboard units.

Costs of installation of these retrofit systems will vary, depending upon the method required. In general, these costs would be:

- o household/small civic buildings

- circulating pump	$ 400
- hot water coil	300
- automatic temperature regulation	150
- valves, connecting pipe	150
- connection to distribution system, trench, valves, piping, meter	1000
	$2000 per load

- o Larger heating loads (school, pool, greenhouse)

- internal connection costs as above (per heating unit*)	$1000
- additional controls and safety interlock	1500
- add differential for larger circulation pump	1000
- additional piping and valving	500
	$4000

* School has 11 furnaces which will cost (11 x 1000) $11,000 internal connection.

Cost scenarios can be generated for a heat distribution system and thereby, unit energy costs using distances from the diesel generating plant:

- o School (would require a 5 cm dia. distribution system for 75 kW)

- distribution system (820 metres x $185	152,000	
- internal connection	11,000	
- heat recovery equipment	100,000	
Total Costs	$263,000	$263,000
- yearly costs of pumping (elec.*) 23 kW, 2920 hours/year	4,000	

o Town center system

- distribution system (600 metres x 262)	157,000	
- internal connection (assume 10 individual loads)	20,000	
- heat recovery equipment	100,000	
Total Costs	$277,000	$277,000
- yearly costs of pumping*	3,000	

* electricity at $.06/kW.h

Unit energy costs developed on the above senarios vary according to the payback period planned, the actual heating season, the expected demand load compared to available capacity, efficiency of system and operating control characteristics. Assuming a heating season of 2920 hours (1/3 the year), a connected 315 kW load (1/2 available capacity), and a 5 year payback period (at 12%) the costs for the town center system are:

$$\frac{\text{debt retirement + operating costs}}{\text{315 kW x 2920 hours}}$$

$$\frac{\$70,000 + \$3,000}{\text{315 kW x 2920 hours}} = \$.08/\text{kW}$$

If the connected heating load could be more closely aligned with the available heat, this cost would then drop to $.04/kW.h

The school heating system because of the low load and large distance, results in a much higher unit energy cost:

$$\frac{70{,}000}{75\ \text{kW} \times 2920\ \text{hrs}} = \$.32/\text{kW.h}$$

This indicates the desirability of steady heating load requirements, such as swimming pool, (approx. 315 kW) additional loads preferentially added, or other such steady base load. It should be noted that user charges by the utility operating the central heating system could be based on a fixed percentage of comparable fuel oil costs thereby retiring the debt over a longer period whilst reducing the running costs of consumers.

6.3.7 Energy Corridor

Inherent within the concept formulation of heat transportation is the availability of defined energy corridors. As in municipal water and sewer systems, right-of-way designation must be set out and recorded and maintained, and access for maintenance must be addressed within the context of community zoning and load use definition. Adjacent/proposed land uses in the corridor areas may determine future system loads (when and if available).

6.3.8 User Fees

Additionally, a rate schedule and connection charges for users must be established to provide adequate remuneration to the operators of a heat recovery system (unless single source). These rates, should a user oriented

system be established, would be based on operating costs, debt retirement, replacement and future extension costs, again, in much the same way as a municipal service is structured. Perhaps, the community should be the operator.

Costs associated with line extensions should be boundary defined (associated with ease of supply) and quantity oriented (as availability increases with electrical demand, more waste heat may be available).

Some of the factors which must be reviewed to develop the unit energy cost would be:

- o distance of consumer
- o type of consumer load
- o grade of heat energy
- o degree of "guaranteed" supply required
- o load cycling (peak vs. base load)
- o efficiency of proposed system

6.3.9 B.C. Hydro Requirements

At this point in time, B.C. Hydro have not entered into any agreements relating to the recovery of wasteheat, the location of plant and equipment within or adjacent to their facility, or the surcharge (if any) they may wish to attach to a recovery system. Currently, they are in the business of producing electricity, not heat. However, since a recovery system could essentially increase the amount of extractable energy from the fuel used, a favorable attitude may be expected.

6.3.10 Water Rights

One major consideration is the availability of the Water Rights for Pine Creek. B.C. Hydro reports that two applications are before the Water Rights Commission, although no recent action on these applications has occurred.

6.3.11 System Reliability

The reliability of the waste heat recovery system is very important. However, should the waste heat recovery system supply energy to users in the context of retro-fit systems, then the existing heating system of the user can be maintained at minimal cost and could be available to take over heating loads should the recovery system fail. Conversely, backup alternate heating sources for the waste heat recovery system could be considered.

7.0 CONCLUSIONS

Refined petroleum products are used extensively by residential, community, industrial and commercial sectors in Atlin. Transportation and diesel generated electricity are largest single consumers. As a result of funding by the Federal Department of Energy, Mines and Resources, through the Remote Community Demonstration Program and the desire of the community of Atlin, off-oil opportunities consisting of both economic demand management and reduction measures as well as viable energy supply alternatives, were reviewed.

Wood has traditionally been used as a heating fuel in the Atlin area. The steady increases in the cost of refined petroleum products and electricity, have further attracted residents to use this fuel source. The 1983 consumption rate was approximately 2500 m^3 and if this was the only consumer of wood in the area the supply of wood in the immediate 40 km radius would be expected to last for 1090 years. With an additional estimated 2500 m^3 being harvested for alternate uses such as logging operations the consumption rate could increase to 10,000 hectares thereby reducing the life expectancy of the resource to 545 years. The overall energy equivalent costs per million Btu for fuelwood is significantly less than all other energy costs and as a result wood is presently being used by 79% of Atlin residents for space heating purposes.

Refined oil products are an important mainstay in Atlin. These products are not produced locally and are brought into Atlin by truck. Refined oil products are supplied primarily from Whitehorse, Yukon and are used for heating, transportation, and electric power generation. Home heating oil is the second most important form of space and water heating and appears to the most cost effective utilization of any refined petroleum product in Atlin.

The use of propane in Atlin is important for secondary and tertiary uses, especially for residents not on power grids. This energy source is becoming a viable energy alternative for transportation in the south, but Atlin's isolation from the petroleum resource areas will continue to place constraints on its popularity.

Natural gas as an energy source for Atlin is not feasible until either a pipeline is constructed in the area or local discoveries make it more readily accesible.

Coal fields in British Columbia are continuing to be developed. The surplus of this fuel available from these regions, is attractive but in the quantities that may be required, make this fuel uneconomic. Coal will only have consideration in the area, if future development exposes local deposits of quality and size.

Several geothermal springs are located in the Atlin area. Temperatures vary from 9°C to 29°C. Geographic isolation from the community and the marginal flow of water experienced, reduces the viability of this alternate energy source.

Popularity and new production techniques continue to lower costs of solar power panels. Space and water heating as well as photovolataic power may be viable in the summer but high energy demands exist when the available solar energy is low. The fact that this energy source would require a supplemental form presently makes it an uneconomical alternative.

Recorded gusts of wind at particular times of the day and year would be adequate for wind generation in Atlin. The mean monthly values though, are too marginal even during the "windy seasons", to consider this alternate energy source beyond the supplemental phase.

Although Canada is considered to have a very high quality of peat, conditions in the north make harvesting difficult. Geographic isolation of known peat sources are such that this energy resource cannot be considered economical at this time for the community of Atlin.

The only readily available unused energy source in Atlin today, is the waste heat from the diesel electric generating systems. It is estimated that for each 100 units of fuel energy input to a diesel electric generating system, approximately 40 units are available for conversion from mechanical energy to the electric equivalent. The remainding 60 units are lost to heat energy either through the coolant system or discarded exhaust. Some 70% of the discarded 60 units are available for heat recovery systems. At 100% load on the generators, a heat recovery module could be expected to reclaim about 2,000,000 Btu/hr., or of the energy amount required to heat a 20,000 ft^2 building. At the present demand level of Atlin, this would represent a savings of about $110,000 of fuel oil equivalent. The recovery system would cost about $100,000 for design, building and contingency. Distribution costs would add another $300,000.

Heat distribution from the waste recovery equipment would have to be a minimal distance to combat heat losses associated with fluid transport and the cost of the piping system. A steady heating load or a steady base load is desirable to allow optimum use of the system.

Reliability of this system is important. If consumers of waste heat have retrofit systems, then present heating systems could be maintained as back up. Unit energy costs for the waste heat recovery systems vary according to length of payback periods, actual heating seasons, expected demand load, system efficiency, operating control characteristics and distances to consumers. Consumers could expect to pay between $14.00 per million Btu for closely aligned systems and over $100.00 per million Btu for users at a large distance.

The second alternative energy source that presently appears to be viable is small scale hydro. The economic development of small scale hydro is dependent upon conditions which affect factors such as the initial cost and rate of pay back.

The 4 proposed potential sites vary in locations, requirements, electrical output potentials and of course, initial cost. Site 2 and Site 3 appear to be quite promising given the high cost of diesel generation in Atlin.

Site 2 would have a design rating of 750 kW, a maximum potential of 823 kW using a 36 m head, 48" steel penstock 900 feet long and consuming a quantity of water of at the rate of 2.73 m^3/sec. This would be the least expensive development, but would require extensive load management and diesel peak topping during the winter evening peak loads. Associated lake storage facilities would lessen these concerns.

Site 3 again would have a design rating of 750 kW, and a maximum potential double to Site 2 of 1544 kW. A 68 m head would require only 1.45 m^3/s of water in the same diameter penstock this time being 1800 m long. Again some load management and diesel peak topping would be required, but to a lesser extent than Site 2. Minimal lake storage would provided year round firm power with sufficient water for additional capacity to 1544 kW.

Current cost estimates for construction of the Site 2 run-of-river facility is $1,920,000 and $2,213,500 for Site 2 with storage facilities. On the other hand cost estimates for construction of the Site 3 run-of-river facility would be $2,387,000 and $2,680,000 for Site 3 with storage. The Site 2 and Site 3 development costs are marginally different at this conceptual stage. On this basis Site 3 is considered preferable, owing to the greater scope for future development.

Unit energy costs at Site 2 the first year are expected to be $0.13 kW/hr. and by year 15 only $0.051 kW/hr. The unit energy cost of Site 3 is expected to be higher because of initial capital costs and would result in year 1 costs of $0.154 kW/hr. dropping to $0.06 kW/hr by year 15. These costs compare quite favourably with reported diesel generation costs of only .17 to .20 kW/hr; however, this does not take into account costs such as transmission, distribution and meter reading. The 1984 subsidized cost to

purchase electricity from the B.C. Hydro diesel generating plant in Atlin is $0.0566 kW/hr. The actual reported 1983 cost to produce that electricty in Atlin taking into account all these additonal costs (transmission, distribution and metre reading) was $0.455 kW/hr.

A comparison of the cost to buy electric at the subsidized rate from B.C. Hydro ($0.0566 kW/hr) is at present still below the cost of electricity from Site 2 or Site 3 ($0.060 and $0.065 respectively) after the project has been in operation for 15 years. Still, with Atlin residents looking at a foreseeable higher cost to purchase electricity in the future, the idea of increased self efficiency is appealing. In the words of one Atlin member of the Advisory Planning Commission:

> "This may be the most important reason. For those Atlin residents concerned ... it simply makes more sense to use our own renewable resource to power our community rather than someone elses expensive non-renewable resource. It isn't anything anyone loses sleep about, but some find it a little irksome that we should be so heavily subsidized by "other people's money" ... Even though Atlin has small responsibility for this situation, a good part of the community would still like it changed".

The community of Atlin would like to discuss the possibility of Phase II funding looking at a small scale hydro development on Pine Creek. The community is hopeful that a cost sharing agreement can be developed between British Columbia Hydro and the Federal Department of Energy, Mines and Resources, in order that implementation of this project may proceed.

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APPENDIX I

ENERGY DATA SHEET

Questionnaire circulated to Atlin residents
May 14-25, 1984

Address: **Date:**

_____

OFFICE USE ONLY

1.	Type of Building:	1. Residential 2. Commercial 3. Community 4. Industrial	1. 1 2 3 4
2.	Length of Building Occupancy:	1. Annual 2. Seasonal	2. 1 2
3.	Type of Construction:	1. Wood 2. Log 3. Trailer 4. Other _____	3. 1 2 3 4
4.	Types of Energy Consumed:	1. Wood 2. Oil 3. Electric 4. Propane 5. Coal 6. Other _____ (e.g. kerosene)	4. 1 2 3 4 5 6
5.	Primary Type of Energy Consumed:	1. Wood 2. Oil 3. Electric 4. Propane 5. Coal 6. Other _____	5. 1 2 3 4 5 6
6.	Secondary Type of Energy Consumed:	1. Wood 2. Oil 3. Electric 4. Propane 5. Coal 6. Other	6. 1 2 3 4 5 6

/OVER

OFFICE USE ONLY

7. What is your current rate of consumption per month? — 7.

   a. heating oil per litre _____
      (4.5 litres = 1 gallon)
   b. electricity per kw/hr _____
   c. propane per 100 lb. cyclinder _____
   d. diesel fuel per litre _____
   e. regular gas per litre _____
   f. firewood per cord _____
   g. coal oil (kerosene) per litre _____
   h. other _____

8. What is the maximum distance you would be willing to travel to collect fuelwood? — 8.
   1. 1 mile
   2. 5 miles
   3. 15 miles
   4. 25 miles
   5. greater than 50 miles

9. What is the maximum price you would be willing to pay for fuelwood? — 9.
   1. $50.00
   2. $75.00
   3. $100.00
   4. $150.00
   5. greater than $150.00

10. What do you believe will be Atlin's <u>most important</u> type of energy by the year 2000? — 10. 1 2 3 4 5 6 7 8

    1. fuelwood
    2. geothermal
    3. solar
    4. wind
    5. peat
    6. oil
    7. hydro electric power
    8. other _____ _____

11. Other Comments:

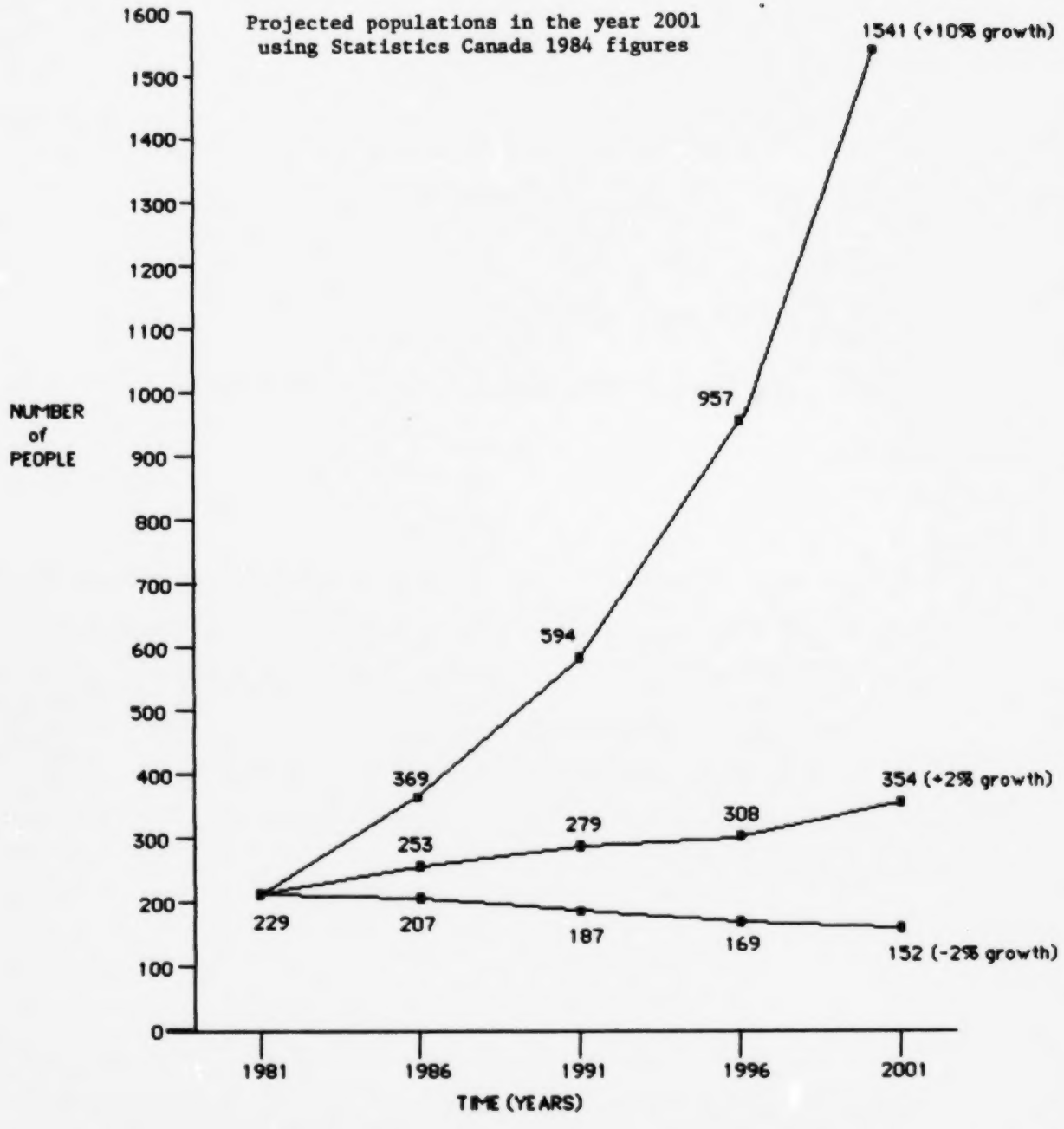
_____

_____

_____

_____

APPENDIX II



Projected Population in the Year 2001 in Atlin
(Assuming a 1981 Population of 229)

APPENDIX III

Community Presentation

INTRODUCTION

WHAT IS THE REMOTE COMMUNITY DEMONSTRATION PROGRAM?

To help reduce dependence on oil, the federal department of Energy, Mines and Resources has established the Remote Community Demonstration Program. This Program is designed to help remote communities and agencies responsible for their energy supply to identify more appropriate energy alternatives and energy conservation opportunities. To do this, the Program offers limited financial assistance for carrying out studies to explore these alternatives and opportunities.

(Note: Phase I of the Remote Community Demonstration Program--the study phase--ends March 31, 1985. Phase II of the program will help fund a limited number of demonstration projects in remote communities.)

QUESTIONS RAISED AT
LAST COMMUNITY WORKSHOP

1. How many community buildings are in Atlin?

2. How many residences are abandoned?

3. How much wind energy is available in the Atlin region?

4. Is electricity a primary heating source?

5. How much wood is available within a 40 km (25 mile) radius of Atlin?

6. What are the current rates of energy consumption?

7. What are the energy equivalent costs per million Btu's?

8. Where do we go from here?

ENERGY NEEDS

OF

THE ATLIN AREA

- What are the energy needs of the community?

- What is the expected rate of population growth in the region?

- What types of energy sources are already available?

- What are the two most feasible long term energy alternatives for the region?

- Where do we go from here?

OVERVIEW

Previously we discussed the opportunities available which were related to:

a) hydroelectric development on Pine Creek

b) recovery of waste heat from the diesel generating station.

Exhibit 1

Hydro Electric

- run of river
- effect of storage
- plant size
- 520 kW winter peak now
- 672 kW projected by 1995 at 2% growth

- Site 2
  - 163 kW run of river
  - 670 kW, .8m storage

- Site 3
  - 306 kW run of river
  - 720 kW, .23m storage
  - 1500 kW, .9m storage

Exhibit 2

Hydroelectric Development Costs

- use site 3 cost data
- base on single 750 kW unit
- estimated cost of $2.7 million

Item	Costs (000's)
turbine/generator	$ 430
mechanical	58
civil works	1355
power line	90
operations	179
storage dam	293
engineering	200
survey	40
construction supervision	35
	$2680

Exhibit 3

Unit Energy Costs:

based on

- connected local factor of 38% in the first year
- 30 year payback period
- 750 kW unit installed
- 8760 hours per year
- allowance for 2% load growth
- allowance for turbine runner replacement after 10 years
- allowance for 2 weeks diesel plant operation per year

first year	17¢/kWh	(38% utilization)
tenth year	7¢/KWh	(100% utilization)

Exhibit 4

Waste Heat - Diesel Electic Plant

- approx. 1/3 of fuel value used develops electrical energy
- remainder of fuel value (2/3) goes into waste heat, noise and vibration
- approx. 70% of waste heat is recoverable
- 400 kW generator at full load provides about 2 million Btu hr
- recovery equipment at plant costs $100,000

Exhibit 5

Waste Heat System

distribution costs (based on 2 million Btu available)

Item	Per Foot	Per Metre
pipe (duplex 4") dia.	$48	$158
trench (8' deep)	5	16
installation	3	10
insulation	12	39
fittings	2	7
backfill/compact	5	16
survey	5	16
	$80	$262

Exhibit 6

Utilization Methods

1. hot water coils in existing hot air systems

2. heat exchanger and circulating pumps retrofit to hot water systems

3. heat exchanger, circulating pumps and hot water baseboard units for other systems

Exhibit 7

Household Retrofit Costs

circulating pump	$400
hot water coil	300
automatic temperature regulation	150
valves/piping	150
connection to distribution	1000
	$2000

Exhibit 8

Larger Heating Loads (School, pool, other)

internal connection per furnace as for household	$1000
additional controls and safety interlock	1500
additional for large circulation pump	1000
additional piping/valving	500
	$4000

Exhibit 9

Town Center System (1 million Btuh)

distribution (600 metres @ $262)	$157,000
individual connections (assume 10 loads)	20,000
heat recovery equipment (at plant)	100,000
yearly cost of pumping	3,000
	$280,000

Exhibit 10

Large Load System (1 million Btuh)

distribution (820 metres @ $262)	$215,000
internal connections (estimated)	11,000
heat recovery equipment (at plant)	100,000
yearly cost of pumping	4,000
	$330,000

Exhibit 11

Unit Energy Costing Factors

- distance of consumer
- type of consumer load
- grade of heat energy
- degree of guaranteed supply required (load shedding)
- load cycling (peak vs base load)
- efficiency of consumer system

Exhibit 12

Unit Energy Costs

$$\text{energy cost} = \frac{\text{debt retire + operating}}{\text{heat load x operating hours}}$$

1. town centre:

$$\frac{\$76,000 + \$3000}{1 \text{ million Btu x } 2920 \text{ hours}} = \frac{\$26.00}{\text{million Btu}}$$

if use all available heat (2 million Btu), cost would reduce to

$$\frac{\$13.00}{\text{million Btu}}$$

2. large single load near school:

$$\frac{\$90,000 + \$4000}{1 \text{ million Btu x } 2920 \text{ hours}} = \frac{\$32.20}{\text{million Btu}}$$

if use all available heat (2 million Btu) cost would reduce to

$$\frac{\$16.10}{\text{million Btu}}$$

3. large single load near B.C. Hydro plant:

$$\frac{\$40,000 + \$3000}{1 \text{ million Btu x } 2920 \text{ hours}} = \frac{\$14.70}{\text{million Btu}}$$

if could use all available heat (2 million Btu) cost would reduce to

$$\frac{\$7.35}{\text{million Btu}}$$

Exhibit 13

Utilization Alternatives

town center	could build to 1 million, and grow to 2 million with additional distribution costs	added costs for system expansion
pool	could use 1 million Btuh as individual load	approx. $1.5 million
greenhouse	could build to 1 million Btuh or larger	size dependant, about $\$50/ft^2$, minimum cost $500,000
fish rearing	could build to 1 million Btuh or larger	size dependant, about $\$80/ft^2$, minimum cost $500,000